Popular Science

MILK NUTRIENTS

S N MAHINDRU

NATIONAL BOOK TRUST, INDIA

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COMMENTS ON THE FIRST EDITION

The chapters like milk fat, milk proteins, processing of milk products and vitamin losses deal with actual nutritional aspects.

Indian J. Anim. Sci. 54 (6) 00-601 June 1984 Reviewer N.C Ganguli.

The book can serve as a pleasant reading material for the beginners.

Indian J. Anim. Sci. 54 (6) 00-601 June 1984 Reviewer N.C. Ganguli.

The author explains the various varieties of preparation of milk and milk products, its health and medicinal value and usefulness. He emphasises the healthy properties of ghee and advocates its widespread use.

Patriot, 22nd May 1983

Reviewer D.A. George

He describes the various preparations of milk that can counteract pathological disorders. In this respect, the book can be a good guide to those who desire to lead a healthy life with milk diet.

Patriot, 22nd May 1983

Reviewer D.A. George

The author, has tried to pool all the information available up-to-date about the value of milk and scientific developments covering the dietary aspects of milk as well as the technology involved in its handling and processing and its nutritional evaluation.

Jour. Res. Ay. Sid., Vol. III No. 3 & 4 pp. 229-232 Reviewer R.C. D. Nautiyal

It is hoped that the publication will be of significant value for students of nutritional sciences, dieticians working in the hospitals as well as researchers in the field of lipid metabolic disorders.

Jour. Res. Ay. Sid., Vol. III No. 3 & 4 pp. 229-232 Reviewer R.C. D. Nautiyal

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S. N. Mahindru

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First Edition 1982 (*Saka* 1904)
Second Edition (Reprint) 1988 (*Saka* 1909)

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Acc No — 15501

Rs. 8.00

Published by the Director, National Book Trust, India, New Delhi-110016 and printed at Bharat Mudranalaya, Shahdara, Delhi-110032

FOREWORD

MILK AND milk products have been the choicest item of food in the diet of the Indian people from time immemorial and these products are equally liked by all communities in the country. Several references to the various beneficial qualities of milk and its products for health and the well-being of the people are to be found in our scriptures. In the medical literature of the hoary past, there is mention of various therapeutic uses of milk and milk preparations for treatment of different ailments. There was, however, no follow-up of the early understanding of the qualities of milk with systematic and scientific studies to enlarge the area of knowledge. Several countries stole a march over us in accumulating a vast storehouse of knowledge through methodical and scientific studies on the physical and chemical properties of milk and its biological value.

All round exploitation of knowledge is now an accepted feature of modern times. It tends to overwhelm both the specialists and the intelligent non-specialists, but on one thing there is unanimity of opinion: that new information contains much that can be utilised with advantage, provided it is properly located.

On the subject of milk, the author has helped to bring the readers up-to-date on information of great value as well as that which gives an accurate feel of current developments. His main concern is to provide a scientific insight into various facets of milk science and technology. He deserves to be complimented on putting together in a lucid manner a vast body of information, covering the dietary aspect of milk as well as the technology involved in its handling and processing and its nutritional evaluation.

I am sure, the book will be useful in many ways. It may serve as a source of stimulation and guidance for fresh directions and ideas for attracting fresh creative talent to advance the frontiers of knowlepge in dairy science. The book is valuable as a ready reference work for preparation of scientific papers, development programmes, popular lectures and for class-room teaching. The publication is welcome because the author has welded together into coherent form a mass of information on a topic of importance to dairy scientists and technologists alike.

New Delhi. DR. P. BHATTACHARYA

PREFACE

SCIENTISTS IN India continue investigating the dietary hypothesis of the aetiology of coronary heart disease. Their short-term experiments on human beings have indicated that butter, coconut oil and hydrogenated oils tend to increase serum cholesterol levels when these oils and fats constitute 40% to 60% of the total food calories, a condition not applicable to large sections of the world's populations, especially in India where the highest average intake of ghee per capita per annum is not more than 1.5 kg., a level nutritionally very much deficient.

It has not been corroborated that the dietary cholesterol is either the cause or the precipitating factor in atherosclerosis; nor is there evidence to show that the lowering of serum cholesterol level offers immunity against coronary heart disease.

Despite these facts very well known to the medical profession, the members of this noble art profession have been used inadvertently as advertisers and/or approvers that certain types and brands of oils and their derivatives will prevent, mitigate and even cure diseases of the heart and its arteries. Adding insult to injury, milk and its products have been driven to the position of forsaken foods and nutrients, because of the presence of small amounts of cholesterol in them.

This book has specially been written to project the correct scientific position and state the truth about milk and its products *vis-a-vis* other fats and nutrients. A Herculean effort has gone into condensing the literature on the subject into these few pages with original reference given not only from the point of view of bio-chemical but also from the religious, social and anthropological angles, indicating the due and deserved high place to milk and milk products in our dietary even in their present form of availability through industrialised units.

The moving spirit behind these labours has been Shri F.C. Pahwa of M/s Foremost Dairies Limited, Saharanpur, a true friend, philosopher, guide and inspirer. My sincere thanks to him. I am equally indebted to Dr. Gurdas Singh, Professor and Head of the Bio-Chemistry Deptt. of the Government Medical College, Amritsar and to Dr. S.C. Ray, Professor Emeritus, President, Indian Dairy Conference (1977), who in the best traditions of India's old teachers have been benign enough to vet my draft to improve its presentation. My respectful salutations to them both.

S.N. Mahindru

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CHAPTER I

Milk—The Nectar For Mortals

MILK HAS long been recognised as the most complete single food available in nature for health and as a medicine, preventive as well as curative. The Aryans were the first people to domesticate cattle as long ago as 1500 to 2000 B.C. not only for agricultural purposes but also for utilising their milk and milk products. The ancient seers have pronounced the cow as the manifestation of a visible form of the 'Ultimate'—a sort of nectar for the mortal world. It has been universally recognised that mother's milk is far superior to cow's and these qualities have been explicitly stated in our ancient text.[1] The ancients also noted its flexibility, i.e., milk could be separated into fat and other solids, its life could be extended through heat treatment and its flavour improved by aging and culturing. The plus points of milk also included praise for its derivative—ghee. The elders' blessings declared: "Each dwelling should have ghee in abundance; good ghee and milk should be available in abundance even on tours; drink ghee and perform magnum opus. Blessed are those who have ghee in abundance."[2] The same sages extolled its virtues in these words: "Cow's milk, curd and ghee impart knowledge, radiance like fire, milk from a red-coloured cow cures heart trouble and anemias, mental and bodily diseases; worshipped are those gods who partake of food prepared from ghee."

The Upanishads prescribed the following diet to parents desirous of having progeny well-versed in the Vedas. ["For a son proficient in the first Veda, i.e., Rig—rice cooked in milk with ghee; in Rig and Yajur—rice, curd and ghee; in Rig, Yajur and Sama—rice cooked in water with ghee and for all the four Vedas—rice cooked in *til*, i.e., sesame seeds, mixed with ghee"].[3] *Madhuparaka*, according to Monier-Williams, "is a respectful offering as a dessert to the bridegroom on his arrival at the house of the father of the bride, sometimes consisting of equal parts of curd, honey and clarified butter."[4]

This recipe is still considered important even today at an Aryan wedding—be it a wedding of Sikh, Jain, Buddhist or any other sect of Hinduism. Ths minor variations in this delicacy have been discussed in detail by Goenka.[5]

The celebrated doyen of all Islamic philosophers. Al-Ghazzali (1058-1111 A.D.) in his book, *Ihya-ul-Ulum-ud-Din*, translated into Urdu as *Mazak-ul-Aarafeen*,[6] has emphasised the virtues of cow's milk and ghee, as "the flesh of cow is a *marz* (disease), its milk is *shafa* (health) and its ghee is *dava* (medicine)."

The holy Quran has repeated the truth of the earlier sages by stating "In truth, hath He sent down to thee the book, which confirmeth those that precede it for He had sent down the low and the Evangel afore time, for man's guidance and thus it directs as such" (Q : 3 : 2).

"And in the existence of the cattle, there is great food for reflection, we give you drink of the pure between dregs and blood which is in their bellies—pure milk, easy and agreeable to swallow for those who drink it."[7] (Q : 16 : 66).

The *Holy Bible* says, : "He that killeth an ox is as he slew a man, He that sacrificeth a lamb is he who cutteth off a dog's neck"[8] or "will I eat the flesh of bulls or drink the blood of goats."[9]

Recognising the importance of milk, its source—the cow, was considered a national asset, hence its protection had been enjoined as the duty of the state as duly enunciated in the *Rig Veda*, "One who partakes of human flesh, the flesh of a horse or of another animal, and deprives others of milk by slaughtering cows, O king ! if such a fiend does not desist by other means, then even cut off his head by your prowess. This is the ultimate punishment which can be inflicted on him."[10]

The above ideas are not a romantic idealisation of the early period and as Zimmer has pronounced, it would be wrong to apply modern standards to the system of Hindu medicine, and the age-old experience of intuition demand their rights. He has said: "Rather tardily science enters the scene, with the growth of organic chemistry, explains, what basis the plants and kindred substances are entitled to their mythological reputation; man would have starved and perished, failing to outlive the hardships of the stone age, had he waited for the scientific dietician to explain why he should stick to certain food-stuffs and drugs discovered in his environment; why he should take to this drink or that in order to overcome some trouble of soul and bowel."

"Traditional belief, unable to analyse and criticize its own experience, stands dumbfounded, if asked its reasons for adhering to its materials or for giving free rein to ideas which do not appeal to the modern mind. It can but point to its real experience and fanciful formulas; these reflect a combination of inspiring intuitions, beneficial feats of auto-suggestion and by actual results which may be corroborated later by tardy science."[11]

"Its experiences and discoveries, however, spring from the same genius of intuition and native curiosity which from the dawn of civilisation served to guide man in giving him control over his environment; it has the same source as the spirit active in modern scientific thought, methods and technology."

In his beautiful analysis of the quintessence of Hindu medicine, Zimmer says: "Diet is an important part of Hindu medicine, not only as regards the sick but also as regards the healthy. India, with its peculiarly trying climate, is haunted by epidemics and infectious diseases. Therefore, caution is the watchword of a Hindu doctor. By an elaborate system of dietetics, Hindu medicine teaches man how to keep fit, how to deal carefully with the individual amount of life-strength with which his organisms have been endowed, how to reach old age, how to enjoy a long and healthy life. A balance of humours is needed and can be established primarily through a proper diet."[12]

These are the very teachings of the *Gita*[13], the *Vedas* and the *Bhagawat* which unequivocally support the above ideas, i.e., for perfect health (Sonré mind-Sonré body) and for higher flights of yoga, the control of food is of prime importance. Therefore, one is compelled by faith and experience to adopt old presumptions and get cured rather than wait for its approval by a physician trained in the modern system of science. It is the case not only with India, but also with other ancient systems of medicine practiced on other continents. As reported recently in an editorial in *The Times of India,* dated 21st July, 1972—"When Tom Large Whiskers—a well known

Navajo Indian doctor, was asked to explain the basis of cures practised by the Indian medicinal system, viz., (1) why a green leaf is placed on a festering sore and it is gone in a few hours, (2) why a seriously hurt man is half buried in loose soil and is taken out completely cured of deep flesh wounds, and (3) why a patient eats a meal as surgeons work on him and gets up and walks out of the operation theatre after a major abdominal operation"? He replied, "The trouble with 'White' medicine is that it treats the illness, not the person. Indian medicine believes that there is a part of the mind out of the person, which he does not know about. This is the part of the mind that is the most important in determining whether some one becomes well or remains sick." Similarly, the Chinese system of Acupuncture has been widely acclaimed by the Americans.

Accordingly, for the benefit of Western-educated readers,the use of milk and its products as a medicine have been recorded throughout the text, Which the Western system has never cared to investigate, particularly with regard to ghee; i.e., butterfat.

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CHAPTER II

Reservations Against Meat Products

BESIDES MILK and its products, the other sources of human nutrition are vegetarian foods and non-vegetarian ones. Western medicine has intensely propagated the use of the latter, so much so that it has become almost a belief that without meat, one cannot have a vigorous health because only these foods are rich sources of proteins with high biological values. On the other hand, it has also been propagated that milk fat gives rise to cholesterol—the very cause of atherosclerosis and other maladies resulting from hypercholesterolemia. This one-sided aggressive propaganda has shaken the faith of vegetarians all the world over, Indians in particular, where the majority are vegetarians by religious persuasion alone. Liver extract is administered to strict vegetarians, even when alternatives are available. A sort of proselytisation has been resorted to in the process.

As wisely observed by Hippocrates, "Your food shall be your medicine and your medicine shall be your food". Thus, for vegetarians, what cannot be food cannot also be their medicine. For the common good of society, too, food cannot be an altogether personal choice and according to Indian philosophy, the ends cannot justify the means. Therefore, besides ethical reservations, the ill-effects of meat food need to be discussed.

Dr. Leonard Williams, in *The Practitioner* has said : "Flesh food is a material which of malice aforethought has sedulously been rendered toxic during the animal's lifetime. In the first place, his endocrine defences are interfered with by castration, he is then immobilised and overfed with a view of causing him to develop fatty degeneration of all his organs; and it is when this ugly process is complete that he is regarded as fit for human consumption."

Dr. Andrews Gold, in *Diabetes—Its Causes and Treatment*, has said: "Flesh food finds no place in this (diabetic) regimen, because the ingestion of the butcher's meat increases the toxaemic conditions underlying the diabetic state and reduces the sugar tolerance. On the other hand, the 'no flesh, no stimulation' and especially the unrefined vegetarian diet promotes sugar tolerance."

Dr. Henry Kellog states : "A dead cow or sheep lying in a pasture is recognised as a carrion. The same sort of carcass dressed and hung up in a butcher's stall passes as food, careful microscopic examination may show little or no difference between the fence-corner carcass and butcher-shop carcass' Both are swarming with colon germs and redolent with putrefaction".

Dr. J.M. Jussawala, a well-known naturopath, says: "The underlying cause of practically every disease of the human body is auto-intoxication or self-poisoning. We exclude from our dietary regimen, the flesh of animals, because it doubles the work of our organs of elimination. Besides, it overloads the system with animal waste matter and poisons. It also must be taken into consideration that the morbid matter of the dead animal is foreign and uncongenial to the excretory organs of man, i.e., it is harder for them to eliminate the waste matter of an animal carcass than that of the human body. Moreover, the formation of ptomaines, i.e., corpse poisons like putrescine, cadaverine, neurine, choline and muscarine begins immediately after the death of the animal. This is a serious matter, since meat and poultry are kept in refrigerator for many days and even months before they reach the kitchen green and lividlooking, and sending forth suspicious odours which have to be doctored with chemicals and spices."

This is the exact condition in the advanced countries and even in big cities of the underdeveloped ones. It is also a fact that emotions of fear, worry and anger actually poison blood and tissues, which find their way into the meat of the slaughtered animals tied and dragged in the slaughter-house, with the process of butchering going on before their eyes.

Dr. Bircher-Benner in his famous book, *Food Science for All* has stated : "The most extravagant and poorest kind of food is certainly meat, be it butcher's meat, game, polutry or fish . It causes loss of energy in metabolic combustion, too much acidity in the chemical proportions and moreover poisons the organs, the tissues and the blood with uric acid."

Dr. James Cousins, the famous American poet and critic, has described the dangers of meat-eating in a clear and more vivid way. He says:

"(a) Those (which are) transmitted by diseased flesh due to parasites. These parasites can be rendered harmless by a process of equal cooking. Thus in terms of human economy, one species of parasite will develop into a tape-worm, while another will produce trichnosis. Other maladies likely to develop are pneumonia, anthrase tuberculosis, virulent poisoning and various inflammatory disorders."

"(b) Those transmitted by flesh, usually termed healthy by eliminating all the above factors. These are inherent and responsible for introduction of poisons into the system. When an animal is killed, the waste matter and the poisons passing through its blood and tissues on the way to excretion are cut short in the process and are retained. These are transferred to the human system and tend to production of uric acid in excess of what the body can normally get rid off, thereby setting up a condition called collemia, i.e., uric acid in blood. This leads to serious manifestations like epilepsy, paralysis, asthma, dyspepsia, diabetes, dropsy angina pectoris, anaemia or piles. The effect may not be immediate as the uric acid shall be pushed from blood into tissues. At any moment, a local precipitation of the uric acid may set up acute pain and if in the nose, it may lead to catarrh, shoulder-rheumatism, toegout, stomach or bowel-gastric ulcer or appendicitis, liverjaundice, lung-pneumonia, face-neuralgia or skin-eczema. All these local manifestations may be of the same malady, i.e. retention of uric acid in tissues. Delayed manifestations can lead to Bright's Disease or cerebral haemorrhage or heart failure."

If more testimony is desired, we can have it in an exquisite form in the article entitled "Vital Problem", wherein Charles Brandt states: "The allopathic medicine, notwithstanding the fact that it has always been an advocate for meat, today recognises the meat diet as injurious to human health through the testimony of its most illustrious representatives like Lehmann Dubois-Reymond, Virchow, Metchnikoff, Ponchet, Kellog, Haig, Kleinschrodt, Nyssens, Elmerlee, Krafft, Eblings, Liber, Huchard, Graham, etc."

The death-toll that meat-eating takes has been well described by Dr. Minner Fathergill when he states:"All the bloodshed caused by the warlike disposition of Napoleon is nothing as compared to the loss of life among the myriads of persons who have sunk into their graves through a misplaced confidence in the supposed value of beef and tea."

Nature has endowed each creature with the means to obtain, prepare, eat and digest his food and dispose of his excreta according to its physiology. If this physiology of carnivora and omnivora *versus* herbivora and frugivora including lactovora is analysed, it is observed that the two groups are poles apart.

Bowels : The carnivora and omnivora have a relatively short bowel which allows the rapid explusion of toxic food materials, for flesh food, after intestinal digestion, forms an excellent medium for the growth of putrefactive bacteria.

The herbivora and frugivora including lactovora have, on the other hand, relatively long bowels, because their foods give up their nutrients quite slowly. The foods of this group break down by the process of fermentation, favouring quite a different set of bacteria, so, what is bacteriologically suitable for one is unsuitable for the other, even if the body makes attempts at adjustment. It is noticeable that the excretion of flesh-eaters in noxious, while that of vegetarian animals is less unpleasant and more suitable for formation of compost and incorporation with soil in a natural cycle. This is primarily due to the type of bacteria involved.

Teeth : The first group has long teeth and retractable claws specially adopted for killing and holding the living prey. The second group is not equipped as the first. The ferociousness of some animals like the rhinoceros and the bull is displayed by defensive armaments only. They do not seek out other animals for food but protect their families. Their teeth are different in shape and enamel also.

Jaws : The former have jaws which only open and shut in an up-and-down motion. Their saliva is minus ptyalin—the essential-nitrogenous principle of saliva. As such they secrete perhaps ten times more of hydrochloric acid than vegetarians, which is quite sufficient to dissolve even bones in the digestive tract. The latter's jaws not only open and shut but have a lateral motion for purposes of chewing, pulping and salivating food as a preliminary digestive process. The saliva contains the ferment ptyalin for the proper digestion of starches in grains and other foods.

Liquid Intake : The first group licks up water with the tongue, whereas the latter takes liquids by suction.

Lastly, by an inborn instinct, the hunting animals scratch holes and bury their excreta as soon as it has left the body. On the other hand, cattle droppings are an excellent source of manure for all vegetarian growth as it can be scattered easily.

Anthropologically, too, a meat diet is not suitable for us. Dr. J. Parsad has discussed the subject in detail and has argued: "It is observed that man belongs to the class of frugivorous mammal designated as ANTHROPOIDEA. The family, HOMINIDOE, genus HOMO, exemplifies man, while the immediately preceding family SIMIDOE in the same order, includes the anthropoid ape, viz., the orang-utan, the gorilla and the chimpanzee. Because of the striking similarity of bodily structure and function these simians bear to man, they are very appropriately called ANTHROPOID, i.e. manlike. The distinctiveness of man from these apes depends merely upon certain minor details of little consequence. These simians are exclusively frugivorous by nature. Hence, it stands to reason that man being the contiguous neighbour ought to follow apes in the matter of food and by doing so, he can truly get natural sanction for his dietetic regimen instinctively from the same nature. This will do away with his experimentation with one clean sweep."

It is reported in the ***Ain-e-Akbari*** that the great Moghul, Akbar, held the view : "Providence has prepared a variety of foods for man but through ignorance and gluttony, he destroys living creatures and makes his body a tomb of beasts."

Perhaps this led great thinkers to give a definite opinion against animal foods. A few are reproduced below :

1. "To eat meat is surely barbarous, who can deny that ?"—Swami Vivekanand.
2. "As long as men torture and slay animals and eat their flesh, we shall have wars."—G.B. Shaw.
3. "We manage to swallow flesh, because we do not think of the cruel and sinful thing we do. There are many

crimes which are the creation of man himself, the wrongfulness of which is put down to their divergence from habit, custom or tradition. But cruelty is not of those. It is a fundamental sin and admits of no arguments or nice distinctions."—Rabindranath Tagore.

Similar sentiments are found in the writings of Tolstoy, Maulana Rumi in his *Musnavi*, Maulana Idris Ahmed and Maulana Abdul Karim in his ***Humanitarianism in Islam***. The Vedas advise "Mahimsyat Sarvay Bhutani" and also Manu, the first law giver of man has said, flesh requires killing but killing does not lead to heaven. To clear all ambiguity, he defines killers as those who give counsel or order to kill or cut any limb or one who actually kills or purchases or eats flesh.

CHAPTER III

Milk—The Best Nutrient

THE VIRTUES of milk have been extolled by the ancient Vedic writers.[1] The subject has been discussed here only on so-called modern scientific basis. The ***Sushruta Samhita*** describes the blessings of the priest supervising the first breast-feeding by the mother as "May four oceans, full of milk, constantly abide in both your breasts, you blessed one, for the increase of the strength of the child. Drinking of the milk, whose sap is the sap of immortal life divine. May your boy gain long life, as do the gods by feeding on the beverage of immortality."[2]

Rangappa *et. al.*[3] have described the completeness of milk as a food for the newly-born animal as the sole substitute, at least for a period, for the pre-natal nourishment that the foetus receives through placental circulation. In addition to the maintenance of offspring, the mammary secretion is called upon to supply the energy required for the newly started functions of respiration, digestion and even perhaps as in some species, of locomotion. Not only that, the proximate principles in milk are presented to the infant system in a form most easily digested and supplemented by vitamins and mineral salts so indispensable to life and growth. No less valuable is the immunising property possessed by the mammary secretion which enables the newborn to resist infection to which it is suddenly exposed with little preparation. Smith had isolated (euglobulin and pseudoglobulin) an immune lactoglobulin from one-hour post-parturient colostrum which constituted more than 50% of total proteins. Similarly, high choline and vitamin content[4] of the initial colostrum raised the content of these in the calf's blood in the first week of its birth.[5]

Since colostrum is not a marketed article, further discussion shall be out of place. Even milk contains a large proportion of anti-toxins[6] and a bactericidal substance[7] specific for coliform organism in raw milk which is destroyed on pasteurisation, though others have not found much difference between the pasteurised and raw milk.

For a critical comparison of nutritional superiority of foods, the one defined by McCollum ***et. al.***[8] is the most practical of all. They have stated that the optimum diet is that which promotes best growth, supports high fertility and greatest success in rearing young ones, preserves the characteristics of youth over the years and extends the life-span to its limits. To realise such a diet in practice they found that the milk-food deserved the greatest emphasis, when meat food and others were already available in plenty.[9] The human body contains about 3 kg of mineral matter of which 5/6th is in the bones. The minerals required for the daily food are phosphates, sulphates, potassium, sodium and calcium, while magnesium, chlorine, iron, copper, iodine, manganese, fluorine, molybdenum and zinc may be present in traces. Some of these are available in plenty from milk, whose composition is appended in Annexure I. The above criteria of nutritional superiority were found well matched in milk in later studies.[10]

Sherman *et. al.*[11] have observed the following evidence of nutritional improvement in the life histories of mothers and their young ones where milk occupied a large proportion of the family diet.

1. Increase in the number of young ones produced.
2. Increase in the percentage (and therefore also in the number) of young ones successfully suckled.
3. Better maintenance of body weight by the mother while suckling the young.
4. Higher averge weight of young at the standard weaning age of 4 months.
5. More economical utilisation of the calories of food consumed as well as the body material of the mother in the rearing of the young to the weaning age.
6. Earlier maturity as shown by the age of a female at the birth of her first young.
7. Longer duration of reproductive life, old age being deferred in the same individuals in whom earlier maturity has been induced.
8. Greater success in the rearing of young as shown by an increase, both in numbers and in percentage, of young

reared and by a decrease in the percentage of females failing to bear and rear young ones.

9. Increase in the length of adult life.

Then followed experimental work on school and orphanage children with the findings as under :

Anden[12] found after experiments that a supplementary meal of milk to poorly nourished children had improved the body and mental vigour with an increase of about 20% in the haemoglobin content of the blood. The other investigators who got similar results are Mann,[13] Leighton,[14] ***et, al.***[15]

The cow and its milk have been held sacred in India from the dawn of civilisation and the latter a product much valued for its virtues. Its nutritive value as recorded in oriental medicine is as under.[16]

Cow's milk is very nutritive, tasteful, delicious, digestive, beautifier and adds to satiety. It is good for brain development, reproductive and spermogenetic faculties, longevity, heart, nutrition, general metabolism and virility, etc. It is sweet and appetising. It also helps in the cure of mental depression, low fever, heart diseases, thirst, stomach disorders, anemia, colic pain, hyperacidity, abortion, consumption, asthenia, hypoacidity, vaginal diseases, and eye ailments.

The detailed medicinal uses of milk are as under :

1. Thorn apple poisoning : 1/4 kg cow's milk+11.68 gm of sugar.
2. Glass poisoning in food : Serve milk.
3. Sulphur poisoning : Milk+ghee and Serve.
4. Low fever : Cow's milk, ghee from cow's milk, ginger, sodium bicarbonate and black grapes. Boil and serve.
5. Dysuria, night discharge and burning micturition: Milk+ghee+jaggery. Heat and serve.
6. Conjunctivitis : Cotton dabbed in cow's milk and alum. Foment.
7. For virility: Cow's milk and ghee+honey. Boil and serve.
8. Hyperacidity and biliary trouble : 80 gm milk+5 to 10 gms. of ginger, digest and concentrate. Add sugar, make pills, serve at bed-time; precaution to be taken is—no water to be given.
9. Measles and small-pox fever: Freshly milked cow's milk+ghee+lump sugar.

10. Hemicrania : Condensed cow's milk+almonds+sugar.
11. For chest and heart ailments: Milk+oil of washerman-marketing nut : 10-15 drops.
12. Bone fracture : Cow's colostrum+sugar. Boil and add ghee, lac-powder; (bark powder) cool and serve. Helps in bone setting. Alternatively, 'Arjungach' Terminalia arjuna +milk+ghee+lac+*taramtra* (to be applied at the fractured spot).
13. Anaemia, T.B., and dysentery : Feed milk heated in an iron pan and observe celibacy.
14. Hiccups : Use boiled milk.
15. Retention of urine and distention of abdomen : Milk+water is also good for manual workers.

Similar, though to a less extent, are the curative properties of curd and buttermilk depending upon the constituents of milk available in the milk derivatives.

From the absorption aspect also, milk and its products are much superior as observed from the table of Annexture II.[17]

On diets of milk and its products, the following men of sport have shown their stamina and have shattered the false belief about the superiority of non-vegetarian foods.

In 1899, Gue Egloff, 19 years, rode 1000 miles on long roads in Ireland in four and a half days. George A. Olby won the Dibble Shield in cycling and broke 200 cycling records. Miss Alison, the well-known skating, racing, and swimming champion Geraldine Turnball, the famous ballet dancer, Annette Kellerman, the swimming champion of the sixties, Bill Pickering who swam the English Channel in 1955, Murray Rose and Paul Berger the world champion swimmers, are some of the sport's luminaries to support the undisputed superiority of milk foods.

The hollowness of the claim about the longer life span of the Europeans due to their non-vegetarian food is proved from the observation: "In Britain, with a population about 50 million, we spend £500 million annually trying to bolster up the crumbling health of the nation. Flesh-eating nations have the biggest incidence of cancer and other diseases of degeneration. Thus the above money goes to drug manufacturers, doctors and surgeons."[18] In contrast we have the Hunza people, who are free from the diseases of civilization as their main diet comprises mainly of milk, fruits and cereals.

Milk curd is hard for digestion, but is nourishing. It is a tonic suited to persons with strong digestive powers. Whey has properties similar to those of curdled milk, which is particularly useful in constipation. However, whey from buffalo milk is phlegmatic and generative of oedema. Lactose is used in debility, phthiasis, gastric irritability and for sweetening the food of infants. It is specially useful in the dropsy of cardiac or renal region. As a uterine stimulant, it is prescribed in protracted labour.[18] Sourmilk products and buttermilk have been accepted as excellent sources of roughage and constipation fighters.[19]

In short, milk and its products are the foods which correspond well to the pure foods described in the Gita.[20]

ANNEXURE 1

The Constituents of Cow's Milk

S. No	*Constituent or Groups of Constituents*	*Wt/1 Litre of milk*
1	2	3
1.	Water	860-880 gm
2.	Lipids in emulsion phase :	
	a. Milk fat (a mixture of triglycerides)	30-50 gm
	b. Phospholipids: Lecithin, Cephalins Sphingomyelins	0.30 gm
	c. Sterols	0.10 gm
	d. Carotenoids	0.1.016 mg
	e. Vitamin A	0.1-0.5 mg
	f. Vitamin D	0.4 mg
	g. Vitamin E	1.0 mg
	h. Vitamin K	Trace
3	Proteins in colloidal dispersion :	
	a. Casein (Alpha, Beta, and Gamma fractions)	25 gm
	b. Beta lactoglobulins	3 gm
	c. Alpha lactalbumins	0.0-0.7 gm
	d. Albumins probably identical to blood serum albumins	0.3 gm
	e. Euglobulin	0.3 gm
	f. Pseudoglobulin	0.3 gm
	g. Other albumins in globulins	1.3 gm
4.	Dissolved materials :	
	a. Carbohydrates	
	1. Lactose (Alpha and Beta)	45-50 gm
	2. Glucose	50 mg
	3. Other sugars	Trace
	b. Inorganic and organic salts :	
	1. Calcium	1.25 gm

1	2	3
	2. Magnesium	0.10 gm
	3. Sodium	0.50 gm
	4. Potassium	1.50 gm
	5. Phosphates	2.10 gm
	6. Citrates	2.0 gm
	7. Chlorides	1.0 gm
	8. Bicarbonates, sulphates and lactates	0.32 gm
	c. Water soluble vitamins :	
	1. Thiamine	0.4 gm
	2, Riboflavin	1.5 mg
	3. Pyridoxine	0.7 mg
	4. Pantothenic acid	3.0 mg
	5. Niacin, biotin, folic acid, etc.	3.30 mg
	6. B_{12}	7.0 ugm
	7. Ascorbic acid	20 mg
5.	Trace elements usually present (Lithium, Rubidium, Barium, Strontium, Manganese, Aluminium, Zinc, Copper, Iron, Cobalt and Iodine).	

ANNEXURE II

Coefficient of Absorbability

S. No.	*Kind of food*	*Protein %*	*Fat%*	*Carbohydrate%*	*Energy available%*
1.	Milk and Dairy products	97	95	98	93
2.	Cereals	85	90	98	91
3.	Sugars and starch	—	—	98	98
4.	Legumes	78	90	97	83
5.	Vegetables	83	90	95	91
6.	Fruits	85	90	90	88
7.	Total vegetable foods of mixed diet	84	90	97	92
8.	Meat and fish	97	95	—	87
9.	Eggs	97	95	—	89
10.	Total animal foods of the mixed diet	97	95	98	89

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CHAPTER IV

Milk Fat

THE BENEFICIAL qualities of ghee have been applauded from Vedic times. By observation, the ancient seers concluded that for those who consumed ghee as such or its preparations whereof it was a constituent to become strong in mind and body. They further pronounced that liquid ghee should be used judiciously which, in turn, should make their bodies glisten and their faces radiant; in short, they accepted ghee as life-source itself.

Some of the outstanding merits of milk fat as compared to other edible fats are discussed here of digestibility: The subject stearate content and fat has been partially discussed in the 3rd chapter of (Annexure II).

Mattil *et. al.*[1] reported that it is rather the content of stearate in fat than the melting point which determines digestibility. Scribanti[2] experimenting with tagged glycerides, also reported that stearic acid and pure stearate are poorly absorbed, especially the tristearate. Monostearate with mt. pt. of 74°C was better absorbed than tristearate of mt.pt. 68°C. But Calloway[3] has suggested that the digestibility of stearic acid is not constant but rather a function of other fatty acids contained in the glyceride structure. The digestibility of stearates can also be improved by mixing them with oleate fats which have lower melting points and this is the peculiarity of ghee which has shown the following figures.

MOLAR PERCENTAGE OF GLYCERIDES

	Buffalow ghee	Cow ghee
Fully saturated glyceride	24.3	23.7
Mono Oleo—disaturated	40.1	36.5
Dioleo—monosaturated	35.6	39.8

The Council of Scientific and Industrial Research of New Delhi conducted a detailed study on the comparative nutritive values of ghee, vanaspati of melting point 37°C and 41°C, raw and refined groundnut oil. The Vanaspati Research Planning

Committee, Government of India, in their sixth and final meeting on 24-8-50 reviewed the work done by the following scientists.

1. Dr. V. Subramanyam, Director, Central Food Technological Research Institute, Mysore.
2. Maj. General S.S. Sokhey, Director, Haffkine Institute, Bombay.
3. Dr. V.N. Patwardhan, Director, Nutrition Research Lab., Coonoor.
4. Dr. B.C. Guha.
5. Dr. G. Sankaran.

On the basis of statistical analysis of their work, they opined as follows : "As regards comparative nutritive value of (1) pure ghee, (2) raw and refined groundnut oil, (3) vanaspati of mt. pt. 37°C and 41°C, the balance of experimental evidence places ghee as the best; raw and refined groundnut oil and vanaspati of mt. pt. 37°C fall into one group, and are next best to pure ghee; vanaspati of 41°C comes third in nutritive value.[5]

Kehar *et. al.*[6] found that biological values of proteins as determined with rats receiving ghee is definitely higher than that determined in experiments with rats receiving vegetable oils or vanaspati. Also that the digestibility coefficient of protein is decreased by 26% and biological value by 38% on a fat-free diet as compared to a diet containing ghee.

Srikantia[7] observed from a survey of 3,000 school-children that the primary bottle-neck in the current dietaries of children is calories and not proteins as hitherto believed. Calorie inadequacy, therefore, would seem to have a crucial role in conditioning protein malnutrition. Among the group, 30% of the children were getting an inadequate level of proteins and the incidence of Kwashiorkor was 1.3% and of frank marasmus was 2.3%. Yet the dietary (i.e., calorie deficient) pattern of these childern was the same. Therefore, the development of the two clinical types of protein-calorie malnutrition under these conditions cannot be explained on protein dominant/deficit diets.

Similar observations have been recorded by Someswarah Rao[8], who found that the intake of calories by pregnant women was about 1,750 calories per day and that of protein intake as 49 gm per day, as against the 2,200+300[9] or 3,000+300 cal. and 55 gm protein per day.[10] Dr. Rao further found that among children for every case of Kwashiorkor, there were two cases of marasmus and three to five of vitamin deficiency. These observations were based on an estimated total number of cases in the four southern states of India as 1,20,000/ day, where the per capita consumption of ghee is : 1.40,0.23, 0.45 and 0.71, as against 1.09 seer of all-India in the States of Andhra Pradesh, Kerala, Madras and Mysore (now Karnataka) respectively (1 seer=0.933 kg).

The required high caloric content of diets was obtained by the incorporation of butter fat, i.e., ghee by Srikantia[12] to make up the caloric deficiency. Nearly 40% of total calories had ghee as their source. His report says, "The children tolerated these diets quite well, and gastro-intestinal upset was not a significant problem. Steatorrhea is frequently seen in children suffering from Kwashiorkor and it was because of this that it has been believed that dietary fat (i.e. ghee) is held best during treatment.

Ghee is the only fat which contains butyric acid and caproic acid in appreciable quantities. Besides these, caprylic and capric acids are found in much lower percentages than found in coconut oil only. Sheep and goat ghee has a sizeable percentage and is between the cow and bufallow ghee on one side and coconut and cocoa family oils on the other side. A molar percentage of fatty acid in various types of ghee is appended in Annexure III.

These low molecular acids, C_4 to C_{10}, have an important role to play in the digestibility of ghee. As described earlier [1–3], the digestibility of stearic acid is not constant but a function of other fatty acids. It is these very low molecular fatty acids which help in the digestion of stearate in the form of glycerides.

Another factor upon which the digestibility of fats rests is the presence of calcium and magnesium salts in the diet. Ionised calcium and magnesium combine with free fatty acids to form soaps, which if not easily soluble are excreted in faeces. Cheng *et. al.*[13] observed that these two salts markedly affected the digestibility of fats with high melting points. The omission of these from diets containing such fats resulted in decreased excretion of soaps and improved the digestibility of fats. But in case of ghee, the low fatty acids from C_4 to C_{10}, which comprise about 17% as against 9.3% of stearates, form soluble magnesium and calcium soaps.

The suggestion of Cheng ***et. al***. cannot be accepted, as both calcium an magnesium are much needed minerals, the former for bone formation and the latter for teeth enamel, blood alkalinity and the nervous system. Conclusively milk fat alone provides these minerals, form soluble soaps and do not interfere in the digestive process of high molecular fatty acids.

Regarding calcium and phosphorus absorption, the highest absorption has been found in cases of ghee and lowest for vanaspati of 41°C. The best dietary ratio of calcium to phosphorus is 1.2:1, as opined by Stearrus, G[14]. He showed that the ratio between ionised calcium and phosphorus $(Ca^{++} : P^{---})$ varies with the nutritive requirement at different ages, i.e. 1.5:0 to 2:1 for infants, to about 1:1 for older children. He found that the average milk has Ca:P::1.2:1 and is the common food relied upon for the principal supply of these nutrients. Besides, a slightly acidic intestinal pH favourably influences the absorption of calcium lactose, which promotes the establishment of an acidic bacterial flora, an important dietary factor in calcium utilisation.

The vitamins A and D content, as claimed by the vanaspati manufacturers is considered to be better than ghee or butter. But these are externally added vitamins and not inherent in the products, while in butter and ghee these are availale in natural form. In such circumstances, the vitamin A content of butter fat may be increased to limits like 175000 I.U./lb by the feeding of vitamin B concentrate to the milch cow.[15,16]

Ghee has been extensively used as a preservative-cum-cooking medium in many Ayurvedic and Unani medicines. For example, the *Charak Samhita*[17] has described more than a hundred preparations. Some of them are aphrodisiac, herbal, vegetarian and non-vegetarian, some for cure of fevers, spleen disorders, deep jaundice, leucoderma, madness and sprue dysentery. These have been abridged by Nadkarni[18] and a few are reproduced as ready reference for readers.

1. **Hansadi Ghrita** : Goose flesh prepared in ghee used in cephalalgia and nervous diseases.
2. **Kukuttadi Ghrita**: Fowls flesh in ghee for chronic cough.
3. **Sira Ghrita** : Jackal's flesh in ghee for insanity.

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4. **Chagaladi Ghrita** : Goat's meat in ghee for nervous diseases.
5. **Nakuladya Ghrita** : Mongoose flesh in ghee for nervous diseases.

Internally ghee is given with honey, sugar, mineral ashes (*Bhasmas*) in tymparities, painful dyspepsia and retained excretions. Ghee, sugarcandy or honey mixed together constitutes a medicine for all ordinary complaints of children. Children who incessantly cry and do not suck mother's milk are given sod. chloride mixed with ghee and sugarcandy, according to Pt. J.L. Duveji.

Ghee by itself or mixed with honey is much esteemed as an application on wounds, inflammatory swellings, and blistered surfaces, with either betel or plantain leaves for promotion of quick healing, and as an injector in wasting disease. It is dropped in the nose in coryza and applied to the face to improve the complexion and impart beauty.

According to Darpana, in strong fevers, an emulsion of sandalwood and of old ghee or clarified butter that has been washed a hundred times in cold water, or an emulsion of black pepper and ghee, is used for applying to the body of the patient, followed in about half an hour by a tepid bath and then the patient is made to lie on a bed of the leaves of *Nellumtrlum Speciasum.*

Old ghee of ten or more years has a strong pungent colour and a reddish-brown colour. It is a very valuable external application in pleurisy and painful affections of joints. A Century-old ghee, some specimens of which are quite dry, hard and nearly odourless, appearing more like an earth than an animal product, is first repeatedly washed with cold water and then rubbed with cold water till it becomes a soapy frothy fluid to be used as a linament, in nerve-diseases like insanity, epilepsy and neuralgia, paralysis, cephalalgia and asthma.

It is also used in rheumatic afflictions, stiff joints, burning of the body, hands and feet and affections of the eye.[19] It has a great reputation for reducing the temperature in fevers. For pains in the breast, old ghee and dry ginger powder proves highly beneficial. Maha Ghrita (111 years old ghee) is a demulcent and alleviator of wind and phlegm.

Buffalo ghee is flatulent, cardiac and generative of the secretions of the semen, beneficial in piles and diarrhoea.

Camel ghee is refrigerant and stomachic and is good in the *Vayu* (wind) variety of *Arsa* (piles), useful in convulsions, worms and leprosy.

The milk lipids play the most distinguished role as regards the flavour of the products manufactured from them. These have been described beautifully by Jennes.[20] "Their rich pleasing flavour is not duplicated by any other type of fat and for this reason, milk fat in the from of butter, ice-cream, coffee and whipping cream has stood up remarkably well under the competitive onslaught of cheaper fats and have a significant role in many of the flavour problems which arise with dairy products. The subject of body and texture is closely related to flavours, so far as consumer acceptability is concerned. Undoubtedly the firm body and texture in most dairy products is one factor which makes them so appealing to most consumers. The milk lipids impart a soft, smooth, rich tasting quality and overcome flat, hard, grainy or watery characteristics which are normally encountered in their absence. Thus milk lipids undoubtedly enhance the consumer acceptability of food; they also serve the best interests of human nutrition through the incentive of what tastes good."

That is why margarine and other products manufactured from non-milk sources have to be blended with milk and cream to make them acceptable to consumers.

Dairy fats also contain significant amounts of essential unsaturated fatty acids like oleic acid, a requisite quantity of linoleic and, vit. A, D, E and K which are not available in similar quantities in other fats. In the hydrogenated vanaspati, only vit. A and D are there and that too added externally which any product can possess.

ANNEXURE III

Molaro of Fatty Acids in Ghee (Average)

S. No.	*Acid*	*Buffalow ghee*	*Cow ghee*	*Goat ghee*	*Sheep ghee*	*Camel ghee*
1		2	3	4	5	6
1.	Butyric	10.9	8.8	7.6	8.4	5.9
2.	Caproic	2.8	4.2	4.5	5.4	1·9
3.	Caprylic	1.5	1.6	6.2	5.8	1.1
4.	Capric	2.4	3.2	11.1	10.1	2.1

1	2	3	4	5	6	7
5.	Lauric	3.3	4.4	5.1	6.0	5.7
6.	Myristic	10.5	6.1	11.2	11.8	7.9
7.	Palmitic	28.7	27.9	21.5	20.4	28.3
8.	Stearic	9.3	9.4	7.3	5.4	9.7
9.	Arachidic	0.7	—	0.1	1.3	—
10.	Oleic	27.7	30.0	24.2	22.2	34.1
11.	Linoleic	2.2	4.4	1.2	3.2	3.3

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CHAPTER V

Sterol Metabolism And Heart Diseases

As SEEN from Annexure 1, Chapter III, millk contains 0.10 gm of sterol per litre having 50 gm of fat. Thus ghee contains 0.2% of sterols in its unsaponifiable portion. The principal sterol present in the animal kingdom is called cholesterol, and the sterols mostly found in the vegetable kingdom are called phytosterols. Though present in very small quantities, cholesterol plays a significant part as the precursor in the body for Vitamin D_3, sex hormones, adrenal cortex hormones, bile acids, etc., and at the same time its presence in abnormal quantities in the blood is an indication of maladies like atherosclerosis. This observation led to a significant propaganda against the consumption of dairy fats and milk products. So a detailed discussion on the biosynthesis of cholesterol, its abnormal presence in the blood and whether hypercholesterolemia is the cause or the effect of certain heart diseases has been felt necessary to exonerate the milk cholesterol in the causation of hypercholesterolemia and its consequent effects.

Cholesterol must be considered as the key constituent, both because of its exceedingly wide distribution in the animal body and also because of its obvious significance as the parent substance of many of the steroid hormones and the lipoprotein component of the cells. Of the various natural sterols, cholesterol is most readily absorbed from the gastro-intestinal tract. The amount of cholesterol in the body is the sum of the following tissue contents, brain=28 gms; RBC=5 to 6 gms; aorta=0.03 to 0.2 gms; skin=13 gms; muscle=30 gms; plasma 5 to 6 gms. and liver=3 to 5 gms. Not all these tissue pools of cholesterol are in a dynamic equilibrium with plasma cholestrol or aorta cholesterol.

A number of factors alter the absorption of cholesterol from the gastro-intestinal tract. The presence of fat in the diet increases the efficiency of absorption of cholesterol from the gut, though it varies with the species. Phytosterols and other sterols inhibit cholesterol absorption because these inhibit the enzyme system concerned with cholesterol absorption.[1] Swell[2] ascribed the beneficial effects of bile salts on the absorption of cholesterol to the activisation of the enzyme, cholesterolesterase. They further noted that sod, glyco-cholate and sod. taurocholate were the most effective bile salts in cholesterol absorption. Peterson *et al.*[3] have shown that lecithin increases cholesterol absorption. It is believed that one molecule of bile salt and one of cholestrol combine to effect the esterification of the fatty acid.[4] It is also confirmed that plant sterols like alpha, beta and gamma phytosterol, stigmmasterol and beta sitosterol are not absorbed, though these are present in abundance in the human diet. The sterol content of the various fats is given in Annexure-IV. They do form soluble compounds with bile salts. The consensus is that these sterols (plant sterols) cannot be converted into cholesterol by man and thus beta sitosterol is removed from the body considerably more rapidly than cholesterol and is not accumulated, though Gould[5] reported that beta sitosterol was absorbed in humans, only 10% of that of cholesterol. Cook[6] has concluded that cholesterol is also absorbed by various mammals and birds, lathosterol and 7-dehydro-cholesterol are absorbed by rabbits and not humans. Beta sitosterol from the fats of higher plants, especially cereals, is only slightly absorbed by man and stigmasterol from soyabeans is not absorbed at all. Whatever cholesterol is not utilized in the body is excreted (a considerable amount) in the faeces[7] in the reduced form, i.e., coprostanal. Cholestanol, epicoprostanol, cholestanone, coprostanone, lathasterol, 7-delny drocholesterol, methosterol, 4 alpha methyl-5 alpha cholest-7 en-3 beta ol. These last three sterols and cholesterol are the known tissue constituents. It is recognised that both cholesterol and the bile acids undergo a entero-hepatic circulation with absorption and secretion of each of these materials.

Normally in man 0.5 to 2.0 gms. of cholesterol is secreted into the intestine everyday. [7A]. It has been estimated that 70% of the faecal sterols found during a cholesterol-free diet arose from intestinal secretion and 30% from biliary secretion. [7B] A large portion of the cholesterol in human plasma is in combination with protein. Onclay *et al.*[8] have shown that the beta globulin fraction of the human serum is 8% by weight of free cholesterol and 39% in esters, although this lipoprotein accounts for only 5% of total plasma protein yet it carries 75% of the total serum cholesterol.

FACTORS ALTERING BLOOD CHOLESTEROL

These are classified under two heads (i) physiological (ii) pathological.

(i) Physiological (Age) : The ratio of cholesterol ester to free cholestrol is a rather precise biological constant under normal conditions, which is 73+1.4%, [9, 10, 11]. It changes with species but not with sex and age.[12] In the horse and the cow, it is 0.67, in the dog, the pig and the goose, it is 0.75. But the blood cholesterol level changes with age. According to Gordon and Cohn[13], it was 89 mgm at birth in human infants, it increased to an average of 136 mgm in 5 to 12 months group and became constant at the age of 5 to 6 years. According to Page *et al.*[14] and Sperry ***et al.***[15], there is no relationship between age and blood cholesterol level. Keys ***et al.***[16] have concluded that a pronounced curvilnear relationship exists between age and serum cholesterol level in man, the maximum concentration being reached in the sixth decade.

Race and Sex : Race has no compelling evidence to prove that there is difference in the blood cholesterol level. This level does not change daily.[17] A decrease in the level of blood cholesterol has been noted in women prior to the onset of the menstrual period.[18, 19]. The most striking changes in blood cholesterol have been observed in women's pregnancy. Thus the increase in cholesterol begins after the second month and continues up to the 13th week, after which it decreases up to the time of delivery.[20]

DIETARY FATS

The causation of hypercholesterolemia due to fat administration has been challenged by Keys ***et al.***[21] Tolstai[22] observed a continuous hypercholesterolemia in individuals who had an exclusive meat-fat diet for over a year. Increased serum cholestrol is also reported in men when cholesterol is fed in the form of egg-yolk but no such increase was found when doses as high as 20 gm a day were given by Turner and Steiner[23] and

Gardner *et al.*[24] and Keys.[25] On the other hand, the feeding of cholesterol to animals (other than man) is invariably followed by an increased blood cholestrol together with the development of fatty livers. Thus hypercholesterolemia occurs in rats,[26], [27] pigs[27], [28] and dogs.[29] In the case of rabbits fed with cholesterol and bile salts, hyper-cholesterolemia is accompanied by atherosclerosis. Shape[32] observed hypercholesterolemia in the cat, the guinea pig, the swine, and in some men also under conditions of dietary restriction. The presence of essential fatty acids is also a must in the diet for normal cholesterol levels.

The fact that dietary carbohydrate and protein give rise to fat has been known for almost a century. But it was not until Swedley *et al.*[33] proved that yeast cells could grow and accumulate lipids when provided with acetate as the only source of carbon. In recent years, the origin of acetate from carbohydrate (by way of pyruvate) has been conclusively demonstrated and similarly from protein by way of ketogenic amino acids such as leucine and isoleucine. Consequently, acetate in the form of acetylcoenzyme A became destined to lie at the interaction of the great trunk lines of glycosis, tricarboxylic-acid cycle and lipid metabolism.

Thus fats are present in the body not only from dietary fats but also from dietary carbohydrates and proteins. A detailed sketch linking the three diets, i.e., fats, carbohydrates and proteins, their metabolism and further proceeding to biosynthesis of cholesterol in detail is appended for the benefit of student readers in Annexure VI.

(ii) Pathological factors : Hypercholesterolemia is a frequent association of under-secretion of thyroid glands, while hypocholesterolemia results from hyper-secretion of the gland. Subtotal thyroidectomy in man results in hypercholesterolemia.[34] Human cretins present hypercholesterolemia.[35] Many investigators have also proved that blood cholesterol is increased in functional hypothyroidism and myxedema.[36], [37], [38] An exceedingly high blood cholesterol level has been reported in cases of diabetes mellitus.[39], [40] Another disease known as essential xonthomatosis is characterised by blood cholesterol of value as high as 800 mgm/100 ml.

FACTORS ALTERING THE BIOSYNTHESIS OF CHOLESTEROL

1. **Age** : The synthesis proceeds most rapidly in the young as it is needed for rapidly developing tissues. It decreases in adults.
2. **Nutritional State** : During fasting the capacity of the liver to synthesize cholesterol is normally decreased, so is the effect of a restricted calorie diet.
3. **Cholesterol Intake** : Exogenous cholesterol intake reduces the cholesterol synthesis in the liver but not in the skin or intestinal mucosa, though the synthesis is subject to homeostatic regulation.
4. **Fat Feeding** : Every vegetable fat provides cholesterol because of the availability of the acetate molecule as a precursor and the result of oxidation of fatty acids. See Annexure VI. When the level of liver cholesterol is high, a high fat diet has been found to be more efficient in the removal of cholesterol as compared to a low fat diet. It is the effect of total fat content, and not the amount of cholesterol ingested, which determines the serum cholesterol.
5. **Phytosterols** : These block the cholesterol absorption in the liver and tissues and have little effect on the rate of synthesis of endogenous cholesterol.
6. **pH Effect** : The effect of pH on the rate of cholesterol synthesis is profound in the absence of potassium and magnesium. It is independent of the state of intracellular potassium.[41]
7. **Other Diseases** : The synthesis of cholesterol is stimulated in hyperthyroidism and is decreased in hypothyroidism[42,43]. The stress produced by lowering the environmental temperature by 20-28°C did not alter the rate of cholesterol biosynthesis in the athyroid rats.[44]
8. **Effect of Vitamin Deficiencies**
   a. Pantothenic acid—it being a structural unit of coenzyme A its deficiency alters cholesterol metabolism, presumably by limiting the extent of cholesterol genesis. Dumm *et al.*[45] reported that adrenal cholesterol is significantly depressed in this deficiency as

compared to normal-fed rats.

b. The specific activity of the adrenal cholesterol was found to be decreased in all types of deficiency. Lecoq *et al.*[46] suggested that whereas nicotinic acid, pantothenic acid, pyridoxine, mesoinositol and methionine are concerned with the metabolism of cholesterol and fats, vit. A and choline are concerned with that of cholesterol alone. Werthessen *et al.*[47] demonstrated that the efficiency of biosynthesis of C^{14} cholesterol is inversely proportional to the damage of the livers perfused with C^{14} acetate.

9. **High carbohydrate and protein diets** : As observed in Annexure VI, dietary carbohydrates and proteins give rise to fats, these breaking down by the process of B-oxidation to acetate which in the form of coenzyme-A ends up in the bio-synthesis of cholesterol. It has been observed amongst the Japanese that though their diet contains 97% of carbohydrates, they too suffer from cholestrolemia, Thus, excess of dietary carbohydrates and proteins also leads to increased biosynthesis of cholesterol.

As explained above, it is observed that dietary cholesterol is not responsible for hypercholesterolemia etc. What beneficial functions cholesterol performs in the body and why it is a must for the human health have been summarised below with the hope that these shall not be out of place in the present context. Cholesterol is the precursor of the following :

a. Vit. D_3 ; This vitamin is formed by the biological mechanism[48], cholesterol→70H cholesterol→dehydro cholesterol→Vit. D_3. The mechanism has been drawn on the strength of the observation that with aeration, cholesterol can undergo microbiological oxidation to 7-OH cholesterol at pH 7 to 8 and at room temperature like 34°C.[49]

Mahindru *et al.*[50] have shown that the mother's milk deficient in cholesterol content had led to the development of rickets in breast-fed children and defective calcification of the bones.

b. Bile acids : The acids which predominate the bile of man as bile salts are cholic acid, desoxycholic acid, chenodesoxy cholic acid, and litho cholic acid. These are present in the bile as salts of glycine and taurine and the principal physiological function of these salts is to promote the intestinal absorption of water-insoluble compounds such as fats, Vit. A, E, D, K, and carotene in addition to cholesterol.

c. Adrenal cortical hormones : Approximately 28 compounds have been isolated from the gland and out of these six have been found to possess physiological activity. These six compounds are classified as (i) those which have a greater effect on electrolyte metabolism and lack the oxygen substituent, (ii) those which have a greater infiuence upon the metabolic process leading to the transformation of protein into carbohydrate and have the oxygen substituent either as a ketone or a hydroxyl group. Of the first group are : (a) Desoxy corticosterone, and (b) Reichstein's compound. Those belonging to the other group are known generally as Kendall's compounds. Their chemical names are (c) Dehydrocrticosterone, (d) corticosterone, and (e) cortisone. It may be stated that in normal human beings, continued ACTH (Adrenal Cortico Tropic Hormone) injections result in a pronounced drop of free and ester serum cholesterol levels.[51] This explains the fact about the poor utilisation of acetate for cholesterol synthesis and extremely good utilisation of cholesterol for hormone synthesis by the adrenal gland.

d. Sex hormones : For the biosynthesis of progesterone, it is observed that the isotopic content of the urinary pregnanediol is related to that of blood cholesterol, and it is calculated that at least 68% of the diol is derived from cholesterol.[52,53]

It need not be emphasized that if the patients with clinical symptoms of threatened abortion excreted less pregnanediol than in normal pregnancy, abortion occurred. However, if the pregnanediol excretion is normal or rises to that value, the clinical symptoms of abortion subside and the normal pregnancy resumes. Similarly, a low conversion of exogenous progesterone into pregnanediol in cases of threatened abortion indicate that miscarriage would occur.[54] It is calculated that about 800 mgm/day of progesterone must be secreted in the ninth month of pregnancy. Perhaps that explains the observation that the increase in the cholesterol begins after the second month and continues up to the 13th week. There is ample evidence that liver is a major site of progesterone metabolism *in Vivo*.[55, 56, 57]

The conclusion of all the above studies has been reflected in the final recommendation of the Inter-society Commission for Heart Diesease Resources, composed of more than 150 cardiovascular specialists and representatives of 25 leading health organisations. In its most comperhensive report, the commission admits that *there is as yet no final proof that fats and cholesterol cause heart disease in man.*[58]

It further added : "At times urgent public health decisions must be made on the basis of incomplete evidence." To get the national cholesterol level down, the panel specially recommended that the daily intake of cholesterol be reduced from its present level of 600 mgm to 300 mgm. Also, fats of any kind should compose not more than 35% of total calories and not less than 10% should come from saturated fats.[59]

Keeping the above recommendations in view, the individual should not take more than 300 mgm of cholesterol/day. As indicated at the beginning of this chapter, milk fat contains 0.2% of cholesterol, ie., 100 gm of ghee has 200 mgm of cholesterol. In other words, for taking 300 mgm of cholesterol, ghee being the main source, 150 gm of ghee/day can be consumed safely or nearly 54 kgm/head/annum. In India this level is only one kilogram, the highest in Rajasthan, i.e, 3 kilos and followed by Punjab, i.e. 2.7 kilos.[60]

A diagrammatic representation of these important compounds is given in Annexure VII.

ANNEXURE IV

Sterol Content of Oils and Fat

S. No.	*Name of the Sterol Source*	*Sterol Content %*
1	2	3
1.	Beef tallow	0.08—0.14
2.	Butter fat	0.24—0.50
3.	Castor oil	0.5
4.	Coconut oil	0.06—0.08
5.	Cocoa butter	0.17—0.20
6.	Codliver oil	0.42—0.54
7.	Corn oil	0.58—1.0
8.	Cotton seed oil	0.26—0.31
9.	Fish oil (Japanese)	0.3
10.	Halibut liver oil	7.6
11.	Lard	0.11—0.12

1	2	3
12.	Linseed oil	0.37—0.42
13.	Mutton	0.03—0.10
14.	Olive oil	0.23—0.31
15.	Palm oil	0.03
16.	Palm kernel oil	0.06—0.12
17.	Peanut oil	0.19—0.25
18.	Poppy seed oil	0.35—0.50
19.	Rice bran oil	0.75
20.	Sesame oil	0.43—0.55
21.	Shea fat	0.09
22.	Soya bean oil	0.15—0.38
23.	Wheat oil	1.3—1.7
24.	Margarine	0.15—0.24

Source : *Industrial Oil and Fat Products,* by A.E Bailey, 2nd Edition 1951, published by Inter-Science Inc., New York.

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CHAPTER VI

Milk Proteins

PROTEINS ARE generally synonymous with muscular power, energy and notions of courage, boldness and brutal strength when their source is meat in any form. When the source is dairy proteins or vegetable proteins, the impressions that come to mind are calmness, tenacity and sobriety. Precisely the former is stimulation, the latter is stamina. A finer distinction between the two according to Dr. Haig, in his well-known book, *Diet and Food* is as follows :

He compares non-vegetarian food to vegetarian one, like a force in an explosive oil to the same amount of energy in a low burning oil. The user of the former diet appearing more lively and energetic at first will fiind himself at the end of stimulation and available albumins, faced by rapidly falling urea and increasing fatigue, sometimes before the opponent, whose source of albumins is dairy products or a vegetarian source.

Theosophically, too, as Prof. N. Sri Ram has said, the man need not have the energy of the tiger, and the rapacity of the wolf.

The *Gita*[1] has described three types of foods as follows :

1. Foods which increase life, purity, strength, health, joy and cheerfulness (good appetite), which are savoury and oleaginous, substantial and agreeable are dear to the *satvik* (pure).
2. Foods that are bitter, sour, saline, excessively hot, pungent, dry and burning are liked by the *rajasik* and are productive of pain, grief and disease.
3. That which is stale, tasteless, putrid and rotten, refuse and impure is the food liked by the *tamasik*.

Inferentially, the first group will comprise milk and its products, cereals, chapatis, leafy vegetables which do not require the use of spices and condiments. Except milk, the others can be counted in the second group also along with fish, meat and eggs, etc., where spices, etc., are required. Therefore milk proteins coupled with other nutrients are matchless.

This opinion is not merely ethical or sentimental but based on nutritional studies which are appended below.

All proteins contain carbon 50 to 55%, hydrogen 6.0 to 7.3%, oxygen 19 to 24%, nitrogen 15 to 19% and sulphur 0.4%. This relative constancy in elementary composition of proteins from widely differing sources is remarkable in view of the great individual differences in their chemical and physical properties. On hydrolysis, they show a different combination of units of alpha amino acids. Therefore, it is the particular arrangement which confers individuality on the proteins.

On a close scrutiny of these amino acids we find that some of them which are essential, are not synthesized by the body hence must be supplied through food externally. It is observed that these are substitutes of low molecular wt. acids like acetic, propionic, butyric, valeric and caproic, etc., some of which are found only in milk lipids. Hence their close proximity.

The superiority of milk proteins has been established by the following studies :

1. The coefficient of absorbability of milk and dairy products has been found to be 97%[3] which is higher than that of cereals, legumes, vegetables, fruits and mixed vegetables, and is not excelled by meat, fish, eggs and total mixed animal foods.

2. The content of essential amino acids of a few foods reported by Aldo Mei[4] has been found to be the best in milk as under :

		Foods Studied mg/10		*Units gms*
Essential Amino Acids	*Maize*	*Rice*	*Beans*	*Milk*
Tryptophan	38	64	58	90
Threonine	249	233	271	294
Isoleucine	289	279	355	407
Leucine	810	513	537	626
Lysine	180	235	464	496
Methionine + Cystine	197	178	125	213
Phenylalanine + Tyrosine	666	571	586	634
Valine	319	416	319	483
Digestibility of Proteins	80	96	64	100

3. Osborne and Mendel have found that rats comparable in every way can be maintained in body wt. with a smaller intake of lactoalbumin than that of any other of the numerous proteins studied. Lactoalbumin also showed a high supplementary value in mixed rations. Casein, the other chief protein of milk, is highly nutritive in itself and very efficient in supplementing the protein of grain products, i.e. when 9/10 of dietary protein is from one or more cereals and 1/10 from milk, this combination is as efficient as an average American diet which is more economical and within the means of the lower strata of society.

4. Henry and Kon feeding rats with proteins (8%) found the relative nutritive values of 52 for white bread; 76 for cheddar cheese; 75 for a mixture of above two foods (1:1); 71 for potato protein; 89 for milk proteins and 86 for the mixture of the last two (1:1).

They further concluded that milk furnishes the protein of the highest biological and supplementary value much more economically than does any other food of animal origin. The high mineral and vitamin content is very important. Milk fat is available in very finely divided globules, and is well-dispersed. As such an even distribution of fat-soluble vitamins like A,D, E & K is not possible in animal sources other than milk.

5. Recently in India Srikantia[5] has reported that dry skim milk powder has been extensively used as a source of protein to treat cases of protein-calorie malnutrition and found it satisfactory. It was further observed that the nutritive value of diets based on vegetable proteins, unlike that of cereal proteins, can also be considerably improved. For example, vegetable proteins (3 parts) mixed with milk protein (1 part of skim protein) is equivalent to skim milk itself.

Another fact that came to light was that 6 gms/kg milk protein and 120-130 cals/kg body wt. gave the optimal clinical and biochemical response for the Kwashiorkor management, beyond which it was all waste. Not only that, by increasing the calories to 200 cals/kg body weight a level of 4 gm/kg protein was = 6gm/kg protein and 120-130 cal/kg of body wt.

Thus, proteins have a specific role other than that of calorie suppliers. Besides, the vegetable proteins are inferior to milk proteins in their ability to promote regeneration of serum albumin.

Amino acids requirements in young adults according to

Rose[6] are :

Amino Acids	*Amount mgm/kg/body wt.*
Arginine	0
Histidine	0
Tryptophane	7
Phenyl-alanine	31
Lysine	23
Threonine	14
Valine	23
Methionine	31
Lucine	31
Isolucine	20

Reverting to the essential amino acid content of various foods mentioned earlier, it is seen that milk has all the above amino acids in highest quantity, besides their availability in other cereal foods also. It is further seen that by an intelligent combination of milk proteins and vegetable proteins coupled with an increase in calories, the protein needs/kg/day for a particular group can be very low; hence it is economical and within the means of the middle-income man. The recommended dietary allowances of proteins for Indians (Revised 1968 figures) are appended in Annexure VIII.

The low quantum of 50 gm (net protein utility) was emphasized much earlier in 1905 by Dr. Chittenden[8] and that too from milk and vegetable sources as against the then held belief of 100-125 gm. His conclusions are reproduced here :

"The minimum protein requirement of a healthy man under ordinary conditions of life is far below the generally adopted dietary standard and far below the amounts called for by the required state of the generality of the mankind. The case for advocacy for rich protein diet loses all its strength and proteins can be obtained without any difficulty from vegetarian dishes, consisting of bread, cereals, vegetables and milk. Thus, there is no justification to fall upon the meat diet, which is not only physiologically undesirable but also uneconomical and it shall save humanity from inflicting undesirable cruelties on the dumb millions." What a prophecy which needed six decades for the modern tardy science to prove.

ANNEXURE VIII

Recommended Dietary Allowances of Proteins for Indians, 1968

DAILY ALLOWANCES

Group	*Age*	*gm/Kg body wt.*	*Total gm/day*
INFANT*	0-3 months	2.3	—
	3-6 months	1.8	—
	6-9 months	1.8	—
	9-12 ,,	1.5	—
CHILDREN	1 year	1.90	16.5
	2 years	1.72	18.0
	3 ,,	1.70	20.0
	4-6 ,,	1.66	22.0
	7-9 ,,	1.59	35.0
	10-12 ,,	1.48	41.0
ADOLESCENTS	13-15 ,, Boys	1.44	55
	,, Girls	1.40	50
	16-18 ,, Boys	1-33	60
	,, Girls	1-27	50
ADULTS	Man 55 Kg	1.0	55
	Women 45 Kg	1.0	45
	Pregnancy	+ 10 gm/day	55
	Lactation	+ 20 gm/day	65

*The type of dietary protein : Infants (0-6) month milk protein
(6-12) ,, -do- +
Vegetable proteins.
Other Vegetable protein combination with net protein utility ranging from 50-65

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CHAPTER VII

Processing Of Milk Products And Nutritional Evaluation

In INDIA, more than in any other country, milk and its products play a more important role in the people's diet. While other nations may have experimented with various foods, our ancients observed the completeness of milk as a food, and its great flexibility, and also the fact that its life can be extended through heat treatment and its flavour can be enhanced by aging and culturing. Since the nutritional value of milk resides in its constituents like proteins, fats, carbohydrates,minerals and vitamins as well as its palatability, the flavour, aroma, body texture and appearance also are important factors for consideration.

The first process that is indispensable to increase the shelf life of milk products is pasteurisation. This process is based on the findings of Louis Pasteur. It is intended to destroy all pathogenic organisms and nearly all other bacteria (except thermodwine and thermophillic). The heated product must be cooled rapidly to retard the growth of those organisms that survive.

The other processes are 1. irradiation, i.e., sterilization by ultraviolent light, 2. for butter manufacture, ripening through natural micro-organisms present in farm cream or through the agency of special bacterial cultures, 3. evaporation, 4. condensation, 5. dehydration, 6. conversion into cheese, ghee, etc., 7. packing for storage, transportation and retailing, and 8. home preparation, etc.

The effect of these processes on the general appearance, flavour, aroma, body texture, appealing nature to the eye, proteins, carbohydrates, fats, vitamins, and minerals has been recorded here.

Although the heat necessary for pasteurisation should not alter the flavour and composition of milk, yet certain desirable as well as undersirable changes do occur. Amylase, catalase, lipase, peroxidase, phosphatase, protease, reductase xanthine oxidase, etc., naturally present in milk may produce undesirable changes. The enzyme-catalysed changes are generally objectionable from the point of attendant flavour alone, since this means a decreased consumption of milk products, and, consequently, of milk nutrients.

In ultraviolet irradiation, it has been noted that though the temperature rise is slight, cooked or even irradiated flavours may get introduced.

Sterilization, by slow heating to boiling, produces extensive changes in the flavour and composition of milk. Homogenisation of milk prior to sterilization produces finely divided fat globules which are easily digested.

Butter is branded farm-butter and creamery-butter, depending upon the cultures employed for ripening on the farm and in the creamery. The former employs whatever micro-organisms are available naturally, the latter destroys the bulk of the natural organisms in the cream through pasteurisation and conducts the ripening through the agency of special bacterial cultures, which are chosen for their ability to produce the most pleasing aroma and flavour in butter. Consequently, these flavours are more uniform, somewhat stronger, more consistent also and creamery butter has more uniformity than the former. These cultures are a mixture of various species of streptococci having the ability to ferment lactose and citrate. The latter gets converted into diacetyl and this with other flavouring substances is responsible for the distinct flavours and aromas of creamery butter.

Homer *et al.*[1, 2] have elucidated the above mechanism of diacetyl formation as : citrate fermentation→acetyl-methyl-diacetyl-carbinol (less flavour and aroma)→diacetyl.

The ratio of these compounds in finished butter is said to be commonly 15:1. The diacetyl content of various butters is : low flavoured 0.1-0.3 ppm, medium 0.4-0.8 ppm and fully flavoured 0.9-2.0 ppm. Other compounds which contribute to the butter flavour are propionic acid and acetic acid obtained from lactose fermentation. Butyric acid peculiarises the butter flavour from that of margarine.

Regarding ghee, the subject will become too lengthy, but has been fully dealt with in the book *Market Quality of Ghee*, published by the Indian Council of Agricultural Research, New

Delhi, and more will be dealt in another chapter, i.e. "Role of Palatability of the Milk Products."

Protein changes have been extensively studied. Of the numerous studies on the differences of nutritional value of raw and pasteurised milk, Natwig *et al*,[3] have found no such difference. Milk proteins are only slightly affected by the heat of pasteurisation, Shahani *et al*,[4] found that 5% albumin and 9% globulin got coagulated at the lower temperature at pasteurisation. Protein changes due to evaporation and drying make it assimilable by infants who in the normal course cannot tolerate ordinary milk.[5] At the higher temperatures of 90-100°C, thermal decomposition of the proteins take place. Heat-induced acidity develops rapidly and is accompanied by a marked increase in the number of basic amino groups, which combine with lactose to cause the prolonged browning of the milk. The solid content also varies.

Much of the damage to heated proteins has been ascribed to the Maillard's Reaction. It is the combination of amino groups of the lysine or other free amino groups of the other diamino acids with the aldehyde of the carbohydrates to form an enzyme-resistant complex. Such a complex would yield the unchanged amino acids to acidic but not to enzymic hydrolysis of any amino acid. This should be evident on comparison with the results of the analysis of the acid hydrolysates of the unheated and heated proteins.

Since most of the amino acid analyses of heated proteins have been conducted by microbiological means, the relative availability of Maillard Reaction products to micro-organisms and rats or other mammals may be important. According to Friedmann, microbiological assay of heated proteins may not reflect the true loss of biological value of such proteins to man.

Cook *et al*.[6] found that the protein efficiency of the milk decreased in proportion to the degree of heat used in ordinary sterilisation and preheating but the damage was not marked at the common temperatures used. Further investigations on the nature of this damage showed a lactose-protein binding stagewise reaction that was evident in resistance to enzymatic digestion, probably because of new cross linkages.[7] The suggestion has been made that the phenomena might account for different relase rates of certain essential amino acids and acids which, in turn, might be sufficient to interfere with mutual supplementation *in vivo* experiments. The reason being that Block[8] found that freshly prepared and stored evaporated milk proteins have the same pattern of essential amino acids as the proteins of fresh milk and dry skim milk.

Hodson[9] concluded that there was about 10% loss in protein efficiency due to sterilization and that this effect involved mainly the sulphur-containing amino acids.

Mauram *et al.*[10] in an excellent study *in vitro* of the digestion of lysine, methionine, tyrosine and tryptophane in condensed milk, found that there was no destruction of the last three but 8.4% of lysine in evaporated milk was destroyed. Another 11.2% of lysine was inactivated, i.e., 20% lysine was lost due to amino sugar condensation. On the other hand, Siniosis[11] found no statistically significant nutritional difference in evaporated milk (homogenised) in comparison with collective human milk.

Dehydration is conservative with respect to product life, storage, shipment and utilisation.[12] In this process protein change, range from none to severe. Henry *et al*,[13] found no differences in the biological value and true digestibility of spray dried whole milk proteins when preheated to 88°C as opposed to 71°C.

McClure *et al*,[14] reported smooth-surface caries in rats, fed on diets, the proteins of which were derived from different skim milk powders. The incidence of caries varied in a manner paralleling the severity of heat treatment. Replacement of skim milk proteins with an equivalent amount from whey powders on vitamin-free casein showed the same pattern of smooth-surface caries. The genesis of caries from casein implicates a protein involvement rather than lactose alone. Patton[15] lists several nutritional implications due to browning and associated changes, ranging from decreased consumption on account of attended palatability to the production of toxic substances or metabolic inhibition. Much research has been concerned with the sulphur-containing amino acid lysine, as involved in heat-induced changes and browning. Mauram *et al.*[10] reported that there was no destruction of tryptophane, tyrosine or methionine in boiled whole milk, roller or spray dried whole milk, evaporated milk or sweetened condensed milk. Lysine was destroyed to varying degrees in spray dried milk (3.6%). in sweetened condensed milk (4.8%), in evaporated milk (8.4%), in average roller dried milk (13%), whereas in a special 'caramelised' roller product, considerable lysine destruction took place (26.6%). In this study, an amino acid was considered destroyed when it was no longer detectable and could not be recuperated by acid or alkali hydrolysis. Lysine inactivation was : evaporated milk (11.2%), average roller dried powder milk (20%) and caramelised roller dried milk (45.8%).

Hodson[16] reported that neither the processing at a low heat, spray-dried, non-fat dry milk, nor converting it into an instant non-fat dry milk damaged the nutritive value of protein for rat growth.

Although some 400 named varieties of cheese are accorded official recognition in the U.S.A. Actually there are about 20 distincitve types obtained from significantly different processes. Cheddar cheese is by far the best known and most consumed. Processing heat is very mild in most cheese-making operations, hence heat-induced nutrient losses are minimal.

Heating milk causes a precipitation of albumin and globulin (7.6% to-22.4%), which means that the protein content of the whey is correspondingly reduced though there is a greater weight loss when ripening is prolonged (Schwaiz *et al*, [17]). Ripening does not result in nutritional loss *per se.* [18], [19] Dearden[20] found no significant difference in the biological value or true digestibility of the proteins of Cheddar, Cheshire and Stilton cheeses made from winter milk. They also reported that diets contaning any one of these cheeses and whey and mineral supplements were as satisfactory for growth rate as mineralised whole milk powder diets.

Protein losses have been studied in foods during home preparation also. McCollunm and Davies had pointed out as early as 1915 that heat treatment of milk decreases its biological value. Casein heated to 120°C or above has less growth and nitrogen maintenance value for rats, but these values can be restored largely by addition of lysine and partly by histidine.[21] Fairbanks *et al*,[22] found roller dried skimmed milk inferior to fresh milk and scorched milk powder the most inferior of all. Addition of cystine improved the growth of rats fed on lightly heated milk powder but lysine additions were necessary to improve the biological value of scorched milk.

Cook *et al*,[23] found 13-24% losses in skim milk powder proteins as did Fairbanks. They also noted about 9% loss in the biological value of sterilized evaporated milk. No further loss in storage up to 12 months was noted. Henry *et al*,[24] reported deterioration of dry milk proteins in storage largely due to lactose-lysine linkage which is subsequently accelerated by a high moisture content. Hodsod[25] showed that this loss was directly related to the storage temperature when evaporated milk was held for 2 years. The same worker continued with rat tests and the study of the changes produced by sterilisation of evaporated milk. He found supplementation with methionine was a must to compensate the losses.[26]

This is surprising, since similar efforts to supplement heated casein and lactoalbumin,[27] when dry skim milk, autoclaved for 15 or 25 minutes, was found to have lost nearly all protein value for rats; was not improved by supplement of methionine alone, but was largely restored to normal by supplements of lysine alone or lysine with other amino acids.[28] This autoclaved milk incidentally gave normal results in dog-feeding experiments, as did the processed milk diets used by Schroeder *et al*,[29] Mauram *et al*,[30] also found lysine but not methionine or tryptophane either destroyed or inactivated in *in vitro* digestion studies of condensed milk and milk powder.

Most workers seem to agree that the heat used for pasteurisation has little or no effect on the nutritive value of milk proteins.[29],[31],[32],[33],[34]. One should not confuse the heat of pasteurisation with the heat described in the above para.

The principal investigators to locate the causes of heat damage in proteins have been Hanks, Beuk and others. They opine that excessive heat changes the structure of proteins in such a manner that some of the amino acids, especially lysine, aspartic acid and glutamic acid, become bound by a linkage which is resistant to enzymatic action. The amino acids are not actually destroyed, since they can be released by acid hydrolysis. In some instances, the enzymatic release of certain amino acids, especially methionine, can be retarded.[39] Also the essential amino acids need to be liberated from the proteins approximately at the same time to facilitate their effective incorporation into metabolic pathway.[40] This retardation could lead to a decrease in the nutritive value of heated proteins.

In the mixture of proteins and carbohydretes, as they occur in natural foods, additional inactivation of amino acids can occur as some protein-bound amino acids react with sugar to from additional enzyme-resistant combinations. Finally, free amino groups of proteins can react with the aldehyde group of sugars, i.e., the Maillard Reaction, resulting in the destruction of amino acids. This reaction is responsible for the browning observed in some heated or stored foods.[41] The most affected amino acids seem to be histidine, threonine, phenylalanine, tryphtophane and lysine.[42]

In the casein-glucose mixture, some lysine can be inactivted at temperatures as low as 37°C.[43] After 50 days, 66% of the lysine was inactivated. After 30 days at this temperature 90% lysine, 70% arginine, 50% methionine and 30% tyrosine were lost for enzymatic release.

To prevent the browning and subsequent loss in nutritive value of protein rich food, an interesting method has been suggested by Hendrickson *et. al.*[44] This removes glucose by the use of the glucose-oxidase-catalase system.

So far as fats and carbohydrates are concerned, except for certain strong partisans of raw milk, it is generally agreed that the heat required for normal pasteurisation has very lettle effect on these two nutrients.

Evaporated milk, like fresh milk from which it is made, is an excellent source of carbohydrates, fats, and other nutrients. The primary carbohydrate of milk, i.e., lactose, is unaffected by the heat-processing required for forewarming evaporation, homogenisation and sterilization. Sufficient water is present in the finished product to cause crystallisation. Undoubtedly, a very small loss in total lactose content is there by virtue of its combination with the protein in a Maillard Reaction. Grimbley[45] found the combination of protein with lactose even below 80°C. Besides time, the extent of heating in condensed milk production is less severe than in evaporation and sterilisation. Schroeder *et. al.*[29] found that both water and fat markedly inhibited the reactios between carbohydrates and proteins when dried, whole dried, whole, S.N.F. (Solids-Not-Fat) and aqueous solution were autoclaved at a pressure of 1.05kg/

cm^2 for 30 minutes. The fat was considered to have minimal action in comparison to the effect of water in inhibiting the browning reaction.

Milk fat is relatively unaffected by heating, incident in the evaporation and sterilization processes. The differences in the solubilities of alpha and beta lactose are more technical than nutritional.

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CHAPTER VIII

Vitamin Losses In Processing

THE VITAMIN A content of pasteurised milk is unaffected by the temperature changes incident to normal pasteurisation. Evaporated milk is an excellent source of vitamin A. In general, one volume of evaporated milk is equivalent to 2.25 volumes of whole milk, but the vitamin A content of evaporated milk is equivalent to 2.5 volumes of the original fresh whole milk. Henry *el. al.*[1] found that by chemical estimation of vitamin A and carotene, there was no loss during the evaporation process, when compared with raw milk from the bulk tanks. The same worker found that fat-soluble vitamins are unaffected by the condensation process also, and are stable in storage for 12 months at 15°C.

Pasteurised milk is commonly packed in plain glass bottles or in waxed paper cartons. For bulk handling, tin, aluminium and steel tanks are employed. Giroux[2] studied the effect of container inertness on vitamin retention and included rusty milk cans also in his study. He found no effect on vitamin A content, though the iron content in milk had increased considerably due to treatment.

The light transmission characteristics of packaging are of much importance. Burgess *et. al.*[3] found that light of 3000A° could penetrate only one to two mm in a milk layer before it lost 99% of its intensity. Light of 5000A° was capable of penetrating 18 mm under similar conditions. Cox *et.al.*[4] studied the effect of exposure of pastuerised whole milk and skim milk on the retention of Vitamin A. The milk was pooled in amber-coloured glass bottles, plain glass bottles and waxed paper cartons and was exposed to diffused daylight and to short-time irradiation with direct sunlight. Care was taken to avoid temperature changes. It was concluded that amber-glass bottle and paper cartons afforded good protection and plain glass bottles did not present considerable loss of vitamins. Waxed paper cartons were more protective than even amber-glass bottles. These findings were in contrast to the earlier work of Pont,[5] Karal and Cornell who had studied the effects of overwraps on the light-activated off-flavours in milk packed in glass bottles. They found that overwrap screening of both i.e., visible spectrum and ultraviolet light, was more effective than wraps screening the latter only.

Information on the effect of packing on the nutritional value of butter is rather scarce. It appears likely that packing of cheese and butter affects primarily its acceptability, with nutritional effect being of a minor importance.

Since in India ghee and butter are the major forms of use of milk fat, vitamin A losses on processing it are discussed in detail here. The vitamin A content of the new ghee from fresh butter obtained by different types of milk is variable. Under experimental conditions, cow ghee has shown higher vitamin value than the ghee from buffalo or mixed milk. Samples made by the stratification procedure have a vitamin A value 10 to 40% higher than by direct clarification, irrespective of the milk—whether it is raw, boiled or morning milk mixed with raw evening milk.[6]

The rate of reduction in vitamin A content depends upon the species character of the milk used. At the stage when the samples were organoleptically declared 'rejects', 45% of the samples prepared from fresh cow butter showed vitamin A reduction, ranging from 25 to 40% of the value recorded when they were fresh. To register a depletion in the vitamin A content to the same degree as cow ghee at the time of rejection, identical lots of samples from buffalo milk were taken only 30 days (as against 8-10 weeks for cow ghee). The behaviour of the vitamin A values in the ghee samples from mixed milk is intermediate between those of the samples from cow and buffalo milk.

Banerjee *et. al.*,[7,8,9,10,11] have done the major work in this field. The values of vitamin A have been given in terms of blue colour of the Carr Price Antimony Trichloride method and hence have comparable values only, but not absolute ones. De and Majumdar[12] found that losses over vitamin potency of the parent butters were from 10 to 22%, depending upon the time and temperature of heating. Muthanna and Seshan[13] and Majumdar[14] spectroscopically found that losses of vitamin A are great at temperatures of clarification above 100°C, e.g., heating at 125°C for 5 minutes caused a loss of 29% in one case. Exposure to sunlight caused a loss of 34% in 10 minutes and in 30 minutes all vitamin A was destroyed. As stated earlier, in the case of various qualities of milks, ultra-violet light required only 10 minutes to wipe out the vitamin A content. Bannerjee *et. al.*[36] found that heating for 30 minutes, at 125°C, effected a loss of only 16% when butter was converted into ghee and 44% at 156°C for 90 minutes.

It was also observed[36] that vitamin A was found to be stable in ghee for about a month, was reduced to a half during ordinary storage for 6 months and was completely destroyed in a year. Bashir *et. al.*[15] found vitamin A stable upto 125°C, but was destroyed rapidly by aeration. The effect of heat has not been autocatalytic, as is the case with light, i.e., once the fat has been heated, the absence of heat source stops further deterioration. Acidity in ghee is a potent prodestructive factor.

VITAMINS D, E & K

Pasteurisation or heat has little or no effect on these vitamins in milk and so also in the evaporation and condensation processes. In ghee, many studies have not been made, as its vitamin content is low.

B GROUP VITAMINS

Milk is a fair and constant source of thiamine. Previously its destruction was reported as 20-40% but with stainless steel equipment, it is now 3-20% in pasteurisation.[16] Others have reported 14-27% on evaporation and on storage for one year at 15°C it was about 30%.[17] Thiamine losses during dehydration have been reported as 10% in spray drying, 15% in roller drying.[18] According to Hodson[19], all these B group vitamins were intact in the two brands of instant non-fat dry milk. He further added that conversion of a low-heat, non-fat milk into instant non-fat dry milk did not change the content of thiamine.

Evans *et al.*[20] observed that thiamine retention in cheddar cheese amounted to only 8.8% and that 43-73% of the retained thiamine was progressively lost during a storage period of 12 months. Greater loss occurred at a temperature of 14.5°C than at 4.5°C. It is interesting to note that thiamine levels were higher throughout the study in cheese made from Holder pasteurised milk than those of the raw or High Temperature Short Time (HTST) pasteurised milk. Chapmann *et. al.*[21] in a thorough re-study of milk found that thiamine losses were 10% in pasteurisation, 20-30% in roller drying and 30-50% in sterilisation as compared to the original content of the milk taken for these processes.

Riboflavin is heat-stable, especially in acid media, but is light-labile. The effect of heat in pasteurisation, sterilisation and boiling for two minutes reduced the riboflavin content by 5.9% and 3.5%, respectively. Kon *et al.*[22] have pointed out that even this loss is unusual and may be principally due to exposure to light. Therefore, milk is homogenised to make it opaque; otherwise, loss in whole raw milk is 71% in 4 hours in direct sunlight.

However, a dissenting note by Davidon and Geilko (1952) and Manzimit and Artem (1954) quoted by Robert (p. 187) says there was a loss of 21.5% during concentration by the former, 5% to 9% by the latter during boiling effect at atmospheric pressure. It is pertinent to add that effect of light has not been considered in this evaluation; like thiamine, riboflavin is stable in conditions stated above.

The changes during cheese manufacture in this vitamin have been studied in detail. About 23% of the riboflavin present in both raw and pasteurised milk (Holder and High Temperature Short Time methods) was retained in Cheddar cheese.[23],[24],[25]

On a moisture corrected basis, day-old cheese showed 468 ug. of riboflavin and a year after, it was 473 ug.

A similar pattern was found in brick and blue cheeses.

Kon *et al.*[26] found that 50% of riboflavin in milk may be lost in distribution during summer months and up to 20% during the rest of the year due to light penetrating the container. Holmes[27] indicated a progressive loss of this vitamin in cow's and goat's milk kept at 10°C in a domestic refrigerator for 4 days, the loss being 74%. Whereas in another study, Buenner *et al.*[28] found a high retention of vitamin A, carotene and riboflavin of canned, evaporated, dried milk and cheese spread, during storage of 6 months or one year at 36°C to 38°C. As reported earlier, the riboflavin content was not effected.

Regarding the other vitamins of the B group it is generally agreed that pasteurisation does not reduce the niacin content of milk. A microbiological assay showed about 10% more niacin in pasteurised milk due to the release of protein-bound niacin. Vitamin B_6 is sensitive to light.[29] It was further seen that there was no effect of pasteurisation and sterilization on the pantothenic acid and the biotin content of Dutch market milk. The conversion of low-heat-non-fat-dry milk to instant non-fat dry milk did not change the vitamin B_6 content, nor that of niacin and panotothenic acid. In the earlier reported study by Chapmann *et al*., whole B_{12} vitamin was nearly destroyed by sterilisation, 20% by roller drying, 35% by spray drying. But pasteurisation does not effect vitamin B_{12} at all.[30]

Ascorbic acid is another vitamin which has been studied in detail by research workers because it is the least stable of all the vitamins present in milk.

In normal handling procedures, 1.5-2.5 mgm/100 ml may be oxidised to dehydro-ascorbic acid prior to pasteurisation. On pasteurisation, most of the dehydro-ascorbic acid is converted into gluconic acid,which is biologically inactive. During cooling, bottling and storage, the ascorbic acid present in the pasteurised product continues to be oxidised to the dehydro form and the conversion rate is influenced by cupric ions and light exposures which is now eliminated in the stainless steel equipment and closed jacket processing.[11]

Sharp *et al*.[31] and Sasaki *et al*.[32] showed that de-aeration was the most effective method of reducing the loss in ascorbic acid added to milk samples held at 30°C, there being no reduction in its content in 12 hours in de-aerated samples held at reduced pressure and only 1% loss after another 12 hours of storage. Since milk is not a rich source, hence pasteurisation is decidedly justified.

Mineral constituents of milk are another type of much-needed milk nutrients. Pasteurisation has a slight effect on the mineral composition and salt forms. There is a decrease in soluble calcium (0.35) and a decrease in soluble phosphorus (0.78%) at 60°C/30 minutes. Whereas at 78°C/30 minutes, these changes are considerably greater, 9.75% decrease for calcium and 9.53% for phosphorus. Kalozeneoas[33] has shown that there is a reduction in pH as a result of heating milk at 62°C for 30 minutes and an increase of mono-calcium phosphate and a decrease in di-calcium phosphate.

Various varieties of lactic acid cheese, such as cottage cheese and cream cheese, are comparatively poor sources of calcium and phosphorus averaging about 0.15% and 0.07% (Ca) and 0.10% (P). Cheese prepared from whey, such as Myost and Ricolls is richer in whey constituents (especially, water soluble vitamins); whereas special spreads, cheese foods and processed cheese may supply certain nutrients, normally absent in most forms of cheese, by virtue of addition of whey and/or skim milk solids.

Rennet coagulation of milk results in cheese forms that are generally good for calcium and phosphorus sources. Lampert[34] has pointed out that the presence of common salt in cheese manufacture may destroy the picture of the original milk minerals present.

Irvine *et. al.*[34] found that roughly 61% of the calcium and 53% of phosphorus were retained in the Cheddar cheese made from raw milk. No significant difference was observed in the retention of these minerals in Cheddar cheese made with pasteurised (by Holder and H.T.S.T. methods) milk, but a slightly greater retention of phosphorus (ion) was observed. Retention of 57.7% and 46.2% of calcium and 58.7% and 43.3% of phosphorus was noted in brick and blue cheeses, respectively. They further found that the type of soil and feed did not affect the mineral retention of Cheddar cheese.

Mattick[35] found that in hand-pressed Cheddar cheese, a small but definite loss was found of calcium and phosphorus, following curd-cutting and during the making and ripening, whereas in the unpressed Stilton cheese, there was a constantly increasing percentage of loss of calcium and phoshorus that correlated with the increased acidity in the whey until the cheese was removed from the hoops.

Among the ripe cheeses, Cheddar retained 57-58% of the original milk calcium and 50-51% of the milk phosphorus, whereas the Stiltion cheese retained about 6-8% of calcium and only 27% of phosphorus. Stiltion cheese showed a 40% calcium retention in raw curd, 30% of this was lost within two weeks after hooping and by the time of ripening, 85-90% was lost from the crumb.

In India, only Cheddar cheese is made on a factory scale, otherwise it is a cottage industry. The Indian varieties are soft cheese, Dacca variety, Surti cheese and Bandal cheese as well.

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CHAPTER IX

Palatability And Its Role In Nutrition

Palatability in foods has been recognised since Vedic times in India and in other ancient civilisations. The *Gita*[2] has specified that foods which are savoury, agreeable, increase joy and cheerfulness (good appetite) and at the same time increase life, purity, strength and health are dear to men of pure conduct. The food should be oleaginous and substantial also. The *Bhagawat* says, eat that which is tasty and suitable for health. The *Gita*[3] further advises that foods that are bitter, sour, saline, excessively hot, pungent, dry and burning are liked by the *Rajsik* and are productive of pain, grief and disease.

Palatability also depends upon other factors; viz., appearance, smell, bite and texture, besides ethnic and religious requirements. These points are extremely important from the physiological, emotional and sensory aspects. To obtain full gratification and indeed full nutritional value of foods at least by the human species, they must be enjoyable to consume.

I.M. Shore[1] has said, "A food manufacturer ignores, at his peril, the net combination of the afferent and efferent nerve impulses which are set up during the process of biting, mastication. tasting and swallowing of foods."

The entire phenomenon of palatability has been well described by Obell.[4] He opines that this extraordinary complex mechanism, which has its beginnings in the degree of tension and relaxation of the jaw muscles, extends to the root sockets of teeth and includes the myriad components involved in the steriognosis of food in the mouth. This steriognostic or dimensional recognition effect results from the combination of the nerve impulses set up in the tongue, the gums, the lips, the walls of the cheeks and the roof of the mouth. The sensibility and the systematic import of these sensory mechanisms tend to be overlooked, yet each of us who still possesses the original denture knows how easy it is to detect the tiniest grain of silica in spinach.

Carried by the cranial nerves to the central nervous system and thence to the gastro-intestinal tract and radiating throughout the entire body, with appropriate feedbacks like satiety, these oral, nasal and ocular impulses place the texture of food in a completely gustatory class from bland and amorphous best nutritive foods.

Viewed with this background, if butter and its industrial substitute margarine are compared, one finds a vast difference in these two foods. The aroma, flavour, body texture and eye appeal of butter depends upon the selective cultures used for the purpose, a distinction which places creamery butter superior to farm butter, as described earlier (Effect of Processing on Nutrients). It is also stated that in the sale of butter, consumer's acceptability is prime, the nutritional importance is secondary.

In the manufacture of margarine, the same cultures are used as in the manufacture of butter. The manufacturing process involves a series of similar reactions, yet there is always a subtle difference between the flavour of margarine and butter. It is believed that the butyric acid or other substances peculiar to butter fat influence the buttery flavour which is conspicuously absent in margarine.

Butter texture depends upon the original structure of the fat globules as they exist in creams and this structure is maintained in the process of butter-making. Indeed, butter-making is an art and not a science[5] otherwise if cream is worked too much, it will develop the undesirable greasy nature of lard and other shortenings. The sad point is that none of the natural flavours of fats and or oils even has any place in margarine.

In a valiant attempt to give margarine the flavour of butter nearly 17%of the margarine component is milk, as in the USA. Despite using the same butter cultures and processes, to enable margarine as a cheap substitute for bread-spread, the fact remains that when a margarine lump enters the mouth, a residue of margarine which fails to melt at body temperature imparts an undesirable "pasty" sensation in the mouth.[5]

The emulsifying agents naturally present in butter effectively prevent coalescence of water droplets even after the emulsion is heated. Under these circumstances the volatilization of water in the frying process results in the formation of a multitude of tiny droplets which look like foam and are devoid of milk solids settling at the bottom of the frying pan. This made it necessary to add special emulsifying agents to margarine in order to confer upon it the physical proporties of butter emulsion, lest it be inclined to leak and exude on storage and eject particles of oil, causing spattering during frying.

The oil used, considerably in Europe, as an emulsifying agent to soyabean, which has been oxidised and polymerised for the production of hydrophillic groups.[6],[7] Recently, the American industry has adopted the Votator system. Yet some critics in Europe argue that the texture of the product resembles that of butter, to a less extent.[8] In short, it is just like the Indian proverb "Crows trying to ape swans, lose their own identity even."

The superior performance of butter fat in the field of flavour, aroma and taste has already been described (Chapter IV). The same is repeated again. "The much pleasing flavour of butter fat is not duplicated by any other type of fat and for this reason, milk fat in the form of butter, ice cream, coffee and whipping cream has stood up remarkably well under the competitive onslaught of cheaper fats and has a significant role in many of the flavour problems, which arise in dairy products. The subject of body and texture is closely related to flavours so far as consumer acceptability is concerned. Undoubtedly firm body and texture in most dairy products is the one factor which makes them so appealing to most consumers. The milk lipids impart a softer, smoother, richer-tasting qualities and overcome flat, hard, grainy or watery characteristics which are normally encountered in their absence. Thus milk lipids which undoubtedly enhance consumer acceptability of a food item, also serve the best interests of human nutrition through the incentive of good taste."

As aptly said by Little John in an editorial, "It is the flavour of the finished consumer product which is the vital factor."

In another editorial,[9] he impresses upon the role of flavour in the foods to come in 2000 A.D. While agreeing that every nutrient like proteins, carbohydrates, fats, vitamins and minerals have been synthesised, but to persuade people to take this type of food, it should have the necessary flavour and palatability. The other qualities needed for the food are good texture, the right acidity, sweetness and, of course, the flavour which he himself defines is odour *plus* one of the basic tastes outlined above. He asks the flavour industry to bend their energies and thought in this direction, so that an artificial but seemingly real flavour can be found out. Till 2000 A.D. comes, we can safely rely on milk fat in its various forms, as outlined above, for the present and be done with.

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CHAPTER X

Need For Modern Milk Product Factories

INDIA WITH a population of 550 million people has a great problem to provide adequate food, both in terms of quality and quantity. It is a known fact that the country is plagued with under-nutrition and malnutrition. Almost all regions, are afflicted with this under-nutrition and malnutrition especially those pronounced in the vulnerable segments of society. The only solution for this problem, i.e., the eradication of malnutrition, is the production of adequate quantities of food. It must be emphasized at the same time that appeasement of hunger is by no means a solution to the multi-faced problem of malnutrition. Even in the midst of food affluence, malnutrition can and does occur in many parts of the world.

Broadly speaking, of the two different approaches to this multi-faced problem, one is to make food available to the people through increased production, better utilisation of raw materials and sound technology. The role of the food industry in fighting the problem of under-nutrition and malnutrition has been discussed on several occasions in the past and out of this debate have emerged two groups of thinkers which hold diametrically opposed views. One group agrees that food industries can and do make processed foods of high nutritive value but these products are beyond the reach of the lower strata. As such, the food industries do not really make a dent on the problem, on the contrary, they offer a wide variety of nutritious food to the privileged classes.

Dr. Bagchi, Nutritional Adviser to the Ministry of Health, Government of India, has made a careful analysis of the fallacy of this argument. He is of the opinion that the food industries generally process foods which would have decayed and remained unutilised in the glut seasons. In the context of the overall availability of food in the country, the food industries through this step definitely increase the total food available in the country.

His other observation is that processed foods are not the monopoly of either the upper strata or the urban communities. He substantiates his stand by citing the example of the making of nutritious bread to indicate that the use of processed foods, which once upon a time were common only amongst the upper sophisticated classes has gone deeper into the middle class and through the middle class into the lower-income groups.

It has to be remembered, he declares, that food habits, especially in these days of industrialisation and urbanisation always trickle down from the upper strata through the middle to the lower economic strata. This phenomenon of aping is a fact conclusively proved by repeated surveys in all parts of India and in fact, in all parts of the world too. Cigarette-smoking and tea-drinking may be quoted as other examples in this context.

A critical analysis of the data on the surveys conducted in different parts of India regarding diet and nutrition has revealed that the vulnerable segment of our population has the following nutritional deficiencies of a very glaring nature :

(i) Calorie deficiency, (ii) protein deficiency, (iii) Vit. A, and (iv) iron deficiency. The role of milk and its products to alleviate these deficiencies, their palatability, sanctity from religious, ethnic and other considerations has been discussed in the preceding chapters. How these nutrients present in fresh milk get destroyed during milk production and handling and how modern creameries endeavour to prevent this loss has been discussed below.

Among the civilized nations of the world, it is unfortunate that India ranks very low in its standard of dairy sanitation, hygiene and farming. The condition of the poor bacterial quality of village and market milks in India has been aptly summed up by the Directorate of Marketing and Inspection, Government of India, in its various reports published from time to time on the marketing of milk in the country.

These reports say : "The universal Indian practice of allowing the calf to suck a little milk before milking, the practice of milking animals on the street for door-to-door delivery, the dirty udder and unwashed flanks of animals, particularly the buffaloes which wallow in mud, the unwashed and contaminated hands of the milker, his dirty clothes and insanitary habits, e.g., coughing, sneezing and blowing the nose with fingers, smoking ‘beedies’, etc., the disease, if any, of the milker and others handling the product, the filthy conditions of the cattle-shed which expose milk to manurial contamination, the unclean and defective milk vessels, the polluted water supply in villages, the defective transport arrangements, the practice of putting leaves, paper and straw in milk to prevent spilling from open cans, the warm climate of the country so favourable for a rapid growth of bacteria, the ignorance and indifference of persons generally engaged in the milk trade even towards the elementary principles of cleanliness, the open milk pans in shops, the lack of suitable technical and educational facilities to create better understanding in the people concerned, the addition of dirty water to milk, the lack of adequate control by the health authorities, etc., are only a few of the many sources and causes which unfortunately pollute the supply of market milk in India and help to keep its standard low compared to other countries.”

The bacterial count in Indian milks is deplorable when compared to that in English milks. In the latter, the count is not more than 30,000/cc, it used to be 17×10^6/cc in 1916.[1] When the samples of Indian milk were collected from the milk shops, railway stations and street vendors, the count rose to 36.38 million. Fortunately, the samples were free from pathogenic organisms like B.Typhus, tuberculosis, diptheria and cholera, but had coli organism. Simultaneously, samples from healthy animals maintained under strictly aseptic conditions had the unbelievable bacterial count of 292/cc. The question arose at that time whether it was possible to produce and distribute milk of low count in India. The fact that was possible was proved by workers at the ICAR (Indian Council of Agicultural Research), who in their herd’s milk found a bacterial count of 9000/cc. in summer and 2000-3000/cc. in winter. The condition even after 28 years was not better. Verma *et al.*[2] examined about 1,340 samples of milk produced and handled under different conditions. Their findings are tabulated on page 65.

Thus arose the need for modern factories for milk processing, upon which depends the manufacture of other products.

A very startling report of the Directorate of Marketing and Inspection states that large buyers of village-milk find most unexpected articles coming out of the milk cans, pieces of

BACTERIAL QUALITY OF MARKET MILK IN BANGALORE

(Plate count and methylene blue reduction time)

Sample description	*Count/c.c*
1. Individual (Imp. Dairy Res. Institute)	Less than 50,000
2. Herd (Imp. Dairy Inst. & Private owned cows)	less than 100,000
3. Dairy and from animals milked from door to door	less than 50,000
4 Town stables	2 × 10^5 to 5 millions
5. Village	5 × 10^5 to 10 millions
6. Milk hawkers	5 × 10^5 to 5 millions
7. Town dairies	greater than 1 million; max. recorded greater than 90 millions.

bones, bread, ropes and wool being more common amongst other things. Regarding containers, the state of affairs is still woe-begone. Soap, mud, tar and pitch are commonly employed for plugging leaks in milk cans. A more pictorial view can be had from actual photographs[3] of the conditions for the handling of milk in India.

The day's outturn of butter is dumped with the previous day's and floated in fresh buttermilk or water, this being changed after every 24 hours. The collection thus accumulates until there is enough to be converted into ghee, or to be sold to the contractor at intervals, either at his place or in the assembling market. At the butter dealer's shop, the collected butter is stored 'dry' in old kerosene tins for any time up to 12 days.

Davies[4] has noticed that butter fat shows signs of being tallowish at a level of about 1.04% lactic acidity. The raw-milk butter develops a light acid flavour at 0.2-0.5%, estery or alcoholic flavour at 1.5-2.5% and culminates in about 3 weeks' time in a putrifactive smell at 6.0-11.0% free acidity. Rangappa *et al.*[5] have found the causative organism to be a green mould of pencillium type. Davies confirmed the same and found acidium moulds also responsible for it.

When butter is transported to the assembling market, the author has himself seen the unscrupulous way in which this commodity is handled. The most rancid butter is placed on top of the so-called good butter and during transport, the rancid, hydrolytically as well as oxidatively, butter-milk, acting as an emulsifier-cum-preservative percolates down through the whole lump with the entire process taking 4 to 6 hours, i.e., the journey time. The result is that material underneath also gets deteriorated. Some of the poor farmers cannot afford the luxury of 'dry' kerosene tins and instead use the cooking earthen pot as a container and that, too, unrinsed and unwashed. To wrap butter lumps, rags from printed textiles are employed which grace the butter with its dyes and chemicals, used at the time of its manufacture and accumulated during its use and dumping period and placed in muddy corners of the house.

The result has been that the lay consumer has become immune and even inured to its presence and accepts it. Worse still, with the passage of time, his attitude has acquired an unconscious ambivalence, resulting in the categorical statement —'All milk products are adulterated', paradoxically, at the same time, showing great reluctance to pay a slightly higher price for a guaranteed, pure, branded product. But if once his faith and trust is restored and he is assured that by consumption of the hygienic, well-kept and highly nutritious foods, he can enjoy good health and can put in more effort in his daily occupation and shall be free from the doctor's pill, needle and bill, he will be happy to pay and consume these products.

Mr. Mathias of M/s Hindustan Lever, during the deliberations of the All-India Seminar on Food Industry in 1969, organised by the Development Commissioner, Small Scale Industries, has brought home another important aspect of the need for milk factories. He says that the lay consumer is unable to realise that the liquid milk which he consumes is 85% water, and the cost of transporting this water in order to provide an intake of 15% solids is formidable; hence he pleads strongly for the manufacture of dehydrated milk and milk fat, which he can reconstitute in his home.

This various types of containers used for storing and transporting ghee are earthen pots, metallic pots, old kerosene oil tins, goat and sheep skin bags, bamboo baskets (in winter only), leaves, glass bottles and glazed earthenware jars. For wholesale storage, transportation and sale, new tins are employed.

The sanitary conditions in this department also are not exactly rosy and silence seems to be the better part of discretion.

As already stated in Chapter III, it is now well recognised that the nutritional status of an infant is particularly important in the first few months of life. Any nutritional deficiency in the initial months will cause irrepairable deficiency or damage to the physical and mental capacity of the individual, irrespective of the amount of nutrition provided subsequently in the later stages of life, hence the need for perfect body food.

The formulation of a utopian baby food in respect of nutrition is confronted with another problem, i.e., the process of manufacture should be designed specially to suit buffalo milk. Buffalo milk is rich in fat and has to be de-fatted partially. It is this fat which is generally preserved in ghee. It is a wrong notion of the lay public, that even modern ghee-manufacturing plants take recourse to a mixture of various fats like the vanaspati manufacturers. The handling of products has to be in a very hygienic condition, so that no bacterial damage is done to vulnerable or healthy consumers.

Unfortunately, the adulteration of milk and its products has been practised from ancient times. Legislation was in force to stop adulteration and imitation of ghee, as narrated in the famous treatise on state administration by Kautilya in his ***Arthashastra***, imposing a fine of 12 silver coins for the offence. A similar type of statute was current during the subsequent regimes of Sultan Allaudin Khilji and Emperor Akbar.

The advantages of ghee produced in a modern factory are numerous. It has a uniform quality, free from contamination, the lacqured tins providing a good keeping quality, being made out of very low free acidity, hygienically sound and free from bacterial contamination and other diseases likely to come from handling. It is the well-preserved and much-needed nutrients like vitamins and carotenoids, good palatability and, above all, freedom from adulteration which constitute the other plus points. The other nutrients of milk are recovered and utilised, unlike the way these are drained away in cottage manufacture. It is free from price fluctuation and due to a good distribution system is readily available which helps the fixed income group to stabilise its kitchen budget. The F.A.O. has corroborated the fact that such factories have proved beneficial to the producer as well as the consumer and have helped the government in preserving and providing the much-needed nutrients and have thereby avoided wastage.

The social benefits accruing out of this are of no mean merit. The management of these factories, working in cooperation with the Animal Husbandry, Agriculture and Dairy Development Departments of the local governments, have initiated intensive dairy development programmes with a view to augmenting milk production in their respective collection areas. Feeding of milk cattle with concentrates and balanced feeds, cultivation of green fodder all the year round, improvement of the general health of the herd in the area by introducing high-yielding breeds, establishment of artificial insemination centres, improvement of the local breed, control of diseases with adequate veterinary measures have become part of regular programmes. The loans advanced are either interest-free or the rate of interest is very low. Doubtlessly, the poor farmers would not have been able to do this by themselves. They have been rescued from the atrocious clutches of ghee traders and are assured of a suitable price, sale and early, rather an on-the-spot payment for their product. The dishonest adulterating middleman has disappeared, much to the relief of the consumer, health authorities enforcing the prevention of Food Adulteration Acts and grading authorities of these products.

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From times immemorial, milk and milk products have been the choicest items of food in the diet of people everywhere. Containing a mass of information on the subject, this lucidly written book provides a scientific insight into various facets of milk science and technology and their particular application in the Indian context.

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